

MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. LXXII.

FEBRUARY 9, 1912.

No. 4

ANNUAL GENERAL MEETING.

F. W. DYSON, Esq., M.A., LL.D., F.R.S., PRESIDENT, in the Chair.

The Report of the Auditors of the Treasurer's accounts for the year 1911 was read, and is given on p. 222.

The Annual Report of the Council was partly read; see pp. 219 to 345.

The Address was delivered by the President, after which the Gold Medal was handed to Mr. A. R. Hinks, to whom it had been awarded for his Determination of the Solar Parallax from Observations of Eros; see pp. 352 to 365.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 366.

The thanks of the Meeting were given to the retiring Members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

The Rev. Walter Bernard Kendall Francis, Chaplain and Naval Instructor, Royal Navy, Simonburn Rectory, Humshaugh-on-Tyne,

was balloted for and duly elected a Fellow of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Francis Gilbert Brown, Insurance Clerk, 68 Murillo Road, Lee, S.E. (proposed by S. A. Saunder);
The Rev. Thomas Fenton Fyffe, B.A., Trindon Grange, R.S.O., Co. Durham (proposed by the Rev. T. E. Espin);
The Rev. Charles Whitacre, Senior Curate of All Saints', Coventry (proposed by the Rev. T. E. R. Phillips); and
John Woodrow, Convener, Coats Observatory, Paisley (proposed by F. W. Dyson).

REPORT OF THE COUNCIL TO THE NINETY-SECOND ANNUAL
GENERAL MEETING OF THE SOCIETY.

The following table shows the progress and present state of the Society :—

	Patron	Honorary Members	Fellows		Associates	Total
			Compounders	Annual Subscribers		
1910 December 31	1	2	257	442	48	750
Since elected	...	...	+3	+37	+2	...
Deceased	...	-1	-9	-10	-1	...
Resigned	...	...	...	-5	...	...
Since compounded	...	...	+3	-3	...	...
Removed	...	...	...	-6	...	...
1911 December 30	1	1	254	455	49	760

Major Hills' Account as Treasurer of the Royal

RECEIVED.

Balances, 1910 December 31 :—	£	s.	d.	£	s.	d.
At Bankers', as per Pass-book	138	12	11			
Cheque not credited	2	2	0			
In hand of Assistant Secretary on Account of Turnor and Horrox Fund	4	2	0			
				144	16	11
Dividends :—						
£1,250 Metropolitan 3-per-cent. Stock ...	35	6	4			
£2,000 Swansea Corporation 3½-per-cent. Stock	65	18	4			
£3,500 East Indian Railway 3-per-cent. De- benture Stock	98	17	4			
£3,500 London and North-Western Railway 3-per-cent. Debenture Stock	98	17	6			
£4,000 Midland Railway 2½-per-cent. Deben- ture Stock	94	3	4			
£1,000 Lancashire and Yorkshire Railway 3-per-cent. Preference Stock	28	5	0			
£2,000 Gas Light and Coke Co. 3-per-cent. Debenture Stock	56	10	0			
£2,000 Commercial Gas Co. 3-per-cent. Deben- ture Stock	56	10	0			
				534	7	10
Interest on money on deposit at Bankers'				5	19	5
Received on account of Subscriptions :—						
Arrears	155	8	0			
Annual Contributions for 1911	699	6	0			
" " for 1912 in advance	15	15	0			
Admission Fees	81	18	0			
First Contributions	53	11	0			
				1,005	18	0
Composition Fees... ..				152	5	0
Sales of Publications :—						
At Williams & Norgate's, 1910	23	0	1			
At Society's Rooms, 1911	111	10	11			
Sales of Photographs, 1911	50	13	6			
				185	4	6
Income Tax refunded by Commissioners of Inland Revenue				32	13	3

£2,061 4 11

Examined and found correct, January 9, 1912.

F. W. LEVANDER.

HENRY ELLIS.

C. DAVIDSON.

Astronomical Society from January 1 to December 30, 1911.

PAID.					£	s.	d.	£	s.	d.
Assistant Secretary: Salary	...	...	...	...	250	0	0			
Editing Society's Publications	...	...	...	...	50	0	0			
Clerk's Salary, &c.	...	...	...	...	105	0	0			
								405	0	0
House Duty	...	...	...	...	2	12	6			
Fire and Servants' Insurance	...	...	...	...	9	12	6			
								12	5	0
Printing, etc. :—										
<i>Memoirs</i>	...	...	...	...	158	5	8			
<i>Monthly Notices</i>	...	...	...	...	431	1	10			
General Index to <i>Monthly Notices</i>	...	...	...	...	92	2	0			
Lists of Fellows and Miscellaneous	...	...	...	...	63	8	1			
Engraving for <i>Monthly Notices</i> and <i>Memoirs</i>	...	...	...	...	42	16	4			
								787	13	11
Preparation of General Index to <i>Monthly Notices</i>	...	...	...	...				62	0	0
Cataloguing Astronomical Literature for the International Catalogue	...	...	...	...				30	0	0
Reproduction of Photographs for sale	...	...	...	...				55	5	0
Turnor and Horrox Fund, and Council Grant for purchase of Books for the Library	...	...	...	...	21	5	5			
Binding for Library	...	...	...	...	70	5	9			
								91	11	2
Subsn. to <i>Centralstelle für astronomische Telegramme</i>	...	...	...	...	1	2	8			
Telephone Subscription	...	...	...	...	6	10	0			
Telegraphic Address: Registration	...	...	...	...	1	1	0			
								8	13	8
Expenses of Meetings	...	...	...	...	17	2	0			
Lantern expenses	...	...	...	...	4	0	0			
Time Signal: rental of wire	...	...	...	...	5	0	0			
								26	2	0
Postage and Telegrams	...	...	...	...	119	11	4			
Carriage of Parcels	...	...	...	...	1	0	5			
Stationery and Office expenses	...	...	...	...	16	6	6			
								136	18	3
House expenses: Allowance and sundry expenses	...	...	...	...	63	15	8			
Coal, Gas, and Electric Light	...	...	...	...	58	15	11			
Fittings, Repairs, &c.	...	...	...	...	10	8	4			
Sundries	...	...	...	...	5	13	4			
								138	13	3
Contribution towards Cost of Coronation Decorations	...	...	...	...				10	10	0
Coronation Exhibition: Frames for Photographs, and sundry expenses	...	...	...	...				8	5	5
Lee and Janson Fund, Grants to Mrs M'Dowell	...	...	...	...				12	0	0
Repayment to Assistant Secretary of amount due on Petty Cash Account, 1911 January 1	...	...	...	...				15	8	
Cheques outstanding, 1911 January 1, ...	...	...	...	...				16	19	6
Cheque Book and deductions on Cheques	...	...	...	...				13	2	
Balances, 1911 December 30 :—										
At Bankers', as per Pass-book	...	...	...	...	243	13	10			
In hand of Assistant Secretary on Account of Council Grant for purchase of books	...	...	...	...	9	16	7			
In hand of Assistant Secretary on Petty Cash Account... ..	...	...	...	...	4	8	6			
								257	18	11
								£2,061	4	11

Report of the Auditors.

We have examined the Treasurer's account of receipts and expenditure for the year 1911, and have found and certified the same to be correct. The cash in hand on December 31, 1911, including the balance at the bankers', etc., amounted to £257 18s. 11d.

The funded property of the Society is the same as at the end of the previous year.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

A list has been laid on the table of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, together with the amount due against each Fellow's name.

(Signed) F. W. LEVANDER.
HENRY ELLIS.
C. DAVIDSON.

1912 January 9.

Gifts to the General Funds of the Society.

In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2,000 Consols. This was sold in 1899, and stands now in £1,881 14s. London and North-Western Railway 3-per-cent. Debenture Stock.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2,000, free of legacy duty. This now stands in £1,871 1s. 6d. Swansea Corporation 3½-per-cent. Stock.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty. This now stands in £93 11s. 1d. Swansea Corporation 3½-per-cent. Stock.

Trust Funds.

The Lee and Janson Fund: In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334 10s. 9d. East Indian Railway 3-per-cent. Debenture Stock.

	£	s.	d.		£	s.	d.
1911 Jan. 1. Balance of				1911. Grants to Mrs			
Fund	81	16	4	M'Dowell	12	0	0
Dividends, East Indian				1911 Dec. 30. Balance of			
Railway	10	0	9	Fund	79	17	1
	<u>£91</u>	<u>17</u>	<u>1</u>		<u>£91</u>	<u>17</u>	<u>1</u>

The Turnor Fund and the Horrox Memorial Fund: In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464 18s. East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38 15s., the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrox: to this the Society added the sum of £55 15s., and the whole now stands in £103 6s. East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the Library.

	£	s.	d.		£	s.	d.
1911 Jan. 1. Balance of				1911. Books purchased			
Fund	3	16	9	during year	21	5	5
Dividends, East Indian							
Railway	17	1	0				
1911 Dec. 30. Due to							
Fund	7	8					
	<u>£21</u>	<u>5</u>	<u>5</u>		<u>£21</u>	<u>5</u>	<u>5</u>

The Hannah Jackson (née Gwilt) Fund: In 1861 Mrs Hannah Jackson (née Gwilt) gave £300 Consols, which now stands in £309 18s. 6d. East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£	s.	d.		£	s.	d.
1911 Jan. 1. Balance of				1911 Dec. 30. Balance of			
Fund	31	8	5	Fund	40	14	5
Dividends, East Indian							
Railway	9	6	0				
	<u>£40</u>	<u>14</u>	<u>5</u>		<u>£40</u>	<u>14</u>	<u>5</u>

Assets and Present Property of the Society, 1912 January 1.

Balances, 1911 December 31 :—

	£	s.	d.	£	s.	d.
At Bankers', as per Pass-book	243	13	10			
In hand of Assistant Secretary on account of Council Grant for purchase of books ...	9	16	7			
In hand of Assistant Secretary on Petty Cash Account	4	8	6			
				257	18	11
Due on account of Subscriptions :—	£	s.	d.			
16 Contributions of 3 years' standing	100	16	0			
44 " 2 " "	184	16	0			
57 " 1 " "	119	14	0			
4 Admission Fees and First Con- tributions	12	12	0			
				417	18	0
Less Contributions paid in advance				15	15	0
				402	3	0
Due for Publications	19	7	2			
„ for Photographs	3	19	6			
				23	6	8
„ from Williams & Norgate for Publications sold during 1911				14	13	1

£1,250 Metropolitan 3-per-cent. Stock.

£2,000 Swansea Corporation 3½-per-cent. Stock (including the McClean and Farrar Bequests).

£3,500 East Indian Railway 3-per-cent. Debenture Stock (including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (*née* Gwilt) Fund).

£3,500 London and North-Western Railway 3-per-cent. Debenture Stock (including the Carrington Bequest).

£4,000 Midland Railway 2½-per-cent. Debenture Stock.

£1,000 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.

£2,000 Gas Light and Coke Co. 3-per-cent. Debenture Stock.

£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock.

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, &c.

Stock of Publications and Photographs.

Celestial Photographs.

The following is a list of reproductions of Celestial Photographs published by the Royal Astronomical Society for sale to the Fellows:—

R.A.S.

Ref.

No.

1. **Total Solar Eclipse, 1889 Jan. 1.**
W. H. Pickering. Willows, California. 1889 Jan. 1. Photographic Telescope. *Ap.* 13 in. (0'33 m.). *F. L.* 16 ft. (4'88 m.). *Exp.* 10 sec.
2. **Total Solar Eclipse, 1893 Apr. 16.**
J. M. Schaeberle. (Lick Observatory Expedition.) Mina Bronces, Chile. 1889 Jan. 1. Photoheliograph. *Ap.* 5 in. (0'127 m.). *F. L.* 40 ft. (12'2 m.). *Exp.* 2 sec.
3. **Total Solar Eclipse, 1886 Aug. 29.**
A. Schuster. Prickly Point, Grenada, West Indies. 1886 Aug. 29. Coronagraph. *Ap.* 4 in. (0'102 m.). *F. L.* 5 ft. 3 in. (1'60 m.). *Exp.* 20 sec.
4. **Nebulæ in the Pleiades.**
Isaac Roberts. Crowborough, Sussex. 1888 Dec. 8. *Position of Centre*—R.A. 3^h 40^m. Decl. + 23° 46'. Reflector. *Ap.* 20 in. (0'508 m.). *F. L.* 98 in. (2'40 m.). *Exp.* 4 hours.
5. **Nebula M. 74 Piscium (N. G. C. 628).**
Isaac Roberts. Crowborough, Sussex. 1893 Dec. 9. *Position of Centre*—R.A. 1^h 31^m. Decl. + 15° 15'. Reflector. *Ap.* 20 in. (0'508 m.). *F. L.* 98 in. (2'49 m.). *Exp.* 3^h 40^m.
6. **Great Nebula in Orion (N. G. C. 1976).**
Isaac Roberts. Crowborough, Sussex. 1888 Dec. 24. *Position of Centre*—R.A. 5^h 30^m. Decl. - 5° 27'. Reflector. *Ap.* 20 in. (0'508 m.). *F. L.* 98 in. (2'49 m.). *Exp.* 80 min.
7. **Milky Way near M. 11.**
E. E. Barnard. Lick Observatory. 1892 June 29. *Position of Centre*—R.A. 18^h 45^m. Decl. - 6° 24'. Willard Lens. *Ap.* 6 in. (0'153 m.). *F. L.* 31 in. (0'787 m.). *Exp.* 3^h 25^m.
8. **Milky Way near Cluster in Perseus.**
E. E. Barnard. Lick Observatory. 1893 Nov. 3. *Position of Centre*—R.A. 2^h 8^m. Decl. + 56° 40'. Willard Lens. *Ap.* 6 in. (0'153 m.). *F. L.* 31 in. (0'787 m.). *Exp.* 3^h 25^m.
9. **Comet 1893 IV. (Brooks).**
E. E. Barnard. Lick Observatory. 1893 Oct. 21. *Position of Comet*—R.A. 12^h 28^m. Decl. + 16° 15'. Willard Lens. *Ap.* 6 in. (0'153 m.). *F. L.* 31 in. (0'787 m.). *Exp.* 35 min.
10. **Comet 1892 I. (Swift).**
E. E. Barnard. Lick Observatory. 1892 Apr. 7. *Position of Comet*—R.A. 21^h 11^m. Decl. - 0° 50'. Willard Lens. *Ap.* 6 in. (0'153 m.). *F. L.* 31 in. (0'787 m.). *Exp.* 65 min.
11. **Nebula about η Argus (N. G. C. 3372).**
David Gill. Royal Observatory, Cape of Good Hope. 1892 Mar. 3. *Position of Centre*—R.A. 10^h 40^m. Decl. - 58° 57'. Astrophographic Telescope. *Ap.* 13 in. (0'33 m.). *F. L.* 11 ft. 4 in. (3'455 m.). *Exp.* 3^h 12^m.

R.A.S.
Ref.
No.
12.

Portion of Moon (Hyginus-Albategnius).

M. Loewy and P. Puiseux. Paris Observatory. 1894 March 14^d
7^h 28^m 39^s G.M.T. Age 9^d 0^h. Term. + 2° 8 M. Equatorial
Coudé. Ap. 0.6 m. (23.62 in.). F. L. 18 m. (59 ft. 6.6 in.).
Exp. 0.5 sec.

13. Comet 1893 IV. (Brooks).

E. E. Barnard. Lick Observatory. 1893 Oct. 22. *Position of*
Comet—R.A. 12^h 29^m. Decl. + 17° 5'. Willard Lens. Ap.
6 in. (0.153 m.). F. L. 31 in. (0.787 m.). Exp. 45 min.

14. Comet 1893 IV. (Brooks).

E. E. Barnard. Lick Observatory. 1893 Oct. 20. *Position of*
Comet—R.A. 12^h 27^m. Decl. + 15° 42'. Willard Lens. Ap.
6 in. (0.153 m.). F. L. 31 in. (0.787 m.). Exp. 35 min.

15. Comet 1893 IV. (Brooks).

E. E. Barnard. Lick Observatory. 1893 Nov. 10. *Position of*
Comet—R.A. 13^h 1^m. Decl. + 31° 47'. Willard Lens. Ap.
6 in. (0.153 m.). F. L. 31 in. (0.787 m.). Exp. 2 hours.

16. Comet 1892 I. (Swift).

E. E. Barnard. Lick Observatory. 1892 Apr. 26. *Position of*
Comet—R.A. 22^h 20^m. Decl. + 17° 30'. Willard Lens. Ap.
6 in. (0.153 m.). F. L. 31 in. (0.787 m.). Exp. 2^h 25^m.

17. Comet 1892 III. (Holmes) and Nebula in Andromeda.

E. E. Barnard. Lick Observatory. 1892 Nov. 10. *Position of*
Centre—R.A. 0^h 45^m. Decl. + 38° 11'. Willard Lens. Ap. 6 in.
(0.153 m.). F. L. 31 in. (0.787). Exp. 3 hours.

18. Comet 1892 I. (Swift).

E. E. Barnard. Lick Observatory. 1892 Apr. 18. *Position of*
Comet—R.A. 21^h 54^m. Decl. + 10° 47'. Willard Lens. Ap. 6 in.
(0.153 m.). F. L. 31 in. (0.787 m.). Exp. 30 m.

19. Portion of Moon (Alps, Archimedes, Apennines).

M. Loewy and P. Puiseux. Paris Observatory. 1894 Feb. 13^d 6^h
23^m 48^s G.M.T. Age 7^d 20^h. Term. + 9° 3 M. Equatorial
Coudé. Ap. 0.6 m. (23.62 in.). F. L. 18 m. (59 ft. 6.6 in.). Exp.
0.5 sec.

20. Nebula in Andromeda (N. G. C. 224).

Isaac Roberts. Crowborough, Sussex. 1888 Dec. 29. *Position of*
Centre—R.A. 0^h 36^m. Decl. + 40° 30'. Reflector. Ap. 20 in.
(0.508 m.). F. L. 98 in. (2.49 m.). Exp. 4 hours.

21. Jupiter.

E. E. Barnard and W. W. Campbell. Lick Observatory. 1891
Oct. 12. Refractor. Ap. 33 in. (0.840 m.). F. L. 570.2 in.
(14.5 m.). Exp. 15 sec.

22. Cluster M. 13 Herceulis (N. G. C. 6205).

W. E. Wilson. Daramona, Westmeath. 1894 Aug. 5. *Position of*
Centre—R.A. 16^h 37^m. Decl. + 36° 41'. Silver-on-glass Reflector.
Ap. 2 ft. (0.61 m.). F. L. 10 ft. 6 in. (3.2 m.). Exp. 1 hour.

23. Total Solar Eclipse, 1893 Apr. 16.

J. Kearney. Fumfium, West Africa. 1893 Apr. 16. Dallmeyer
Photoheliograph. Ap. 4 in. (0.102 m.), with negative enlarging
lens. Equiv. F. L. 70 ft. (21.35 m.). Exp. 5 sec.

R.A.S.
Ref.
No.

24. **Total Solar Eclipse. 1893 Apr. 16.**

J. Kearney. Fundium, West Africa. 1893 Apr. 16. Dallmeyer Photoheliograph. *Ap.* 4 in. (0.0102 m.), with negative enlarging lens. *Equiv. F. L.* 70 ft. (21.35 m.). *Exp.* 20 sec.

25. **The Moon (Age 7^d 3^h).**

E. S. Holden and J. E. Keeler. Lick Observatory. 1890 Sept. 21^d 14^h 55^m G.M.T. *Term.* + 7° 9 M. Refractor. *Ap.* 33 in. reduced to 8 in. (0.203 m.). *F. L.* 570.2 in. (14.5 m.). *Exp.* 3 sec.

26. **The Moon (Age 12^d 6^h).**

E. S. Holden and W. W. Campbell. Lick Observatory. 1891 Aug. 16^d 17^h 23^m 28^s G.M.T. *Term.* + 59° 3 M. Refractor. *Ap.* 33 in. reduced to 8 in. (0.203 m.). *F. L.* 570.2 in. (14.5 m.). *Exp.* 2 sec.

27. **The Moon (Age 16^d 18^h).**

E. S. Holden and W. W. Campbell. Lick Observatory. 1890 Aug. 31^d 22^h 24^m G.M.T. *Term.* - 72° 8 E. Refractor. *Ap.* 33 in. reduced to 8 in. (0.203 m.). *F. L.* 570.2 in. (14.5 m.). *Exp.* 2 sec.

28. **The Moon (Age 23^d 8^h).**

E. S. Holden and W. W. Campbell. Lick Observatory. 1891 July 28^d 23^h 51^m 40^s G.M.T. *Term.* + 16° 6 E. Refractor. *Ap.* 33 in. (0.838 m.) reduced to 8 in. (0.203 m.). *F. L.* 570.2 in. (14.5 m.). *Exp.* 4 sec.

29. **The Sun.**

Royal Observatory, Greenwich. 1892 Feb. 13. Dallmeyer Photoheliograph. *Ap.* 4 in. (0.102 m.), with negative enlarging lens. *Equiv. F. L.* 70 ft. (21.35 m.). *Exp.* about .005 sec.

30. **The Sun.**

Royal Observatory, Greenwich. 1892 July 8. Dallmeyer Photoheliograph. *Ap.* 4 in. (0.102 m.), with negative enlarging lens. *Equiv. F. L.* 70 ft. (21.35 m.). *Exp.* about .005 sec.

31. **Portion of Moon (Region of Maginus).**

M. Loewy and P. Puiseux. Paris Observatory. 1894 Feb. 13^d 3^h 59^m 39^s G.M.T. *Age* 7^d 18^h 14^m. *Term.* + 8° M. Equatorial Coudé. *Ap.* 0.6 m. (23.62 in.) *F. L.* 18 m. (59 ft. 6.6 in.). *Exp.*

32. **The Moon Age (14^d 8^h).**

E. S. Holden and J. M. Schaeberle. Lick Observatory. 1890 Oct. 27^d 18^h 1^m G.M.T. *Term.* + 88° 2 M. Refractor. *Ap.* 33 in. (0.838 m.) reduced to 8 in. (0.203 m.). *F. L.* 570.2 in. (14.5 m.). *Exp.* 2 sec.

33. **Portion of Moon (Ptolemaeus).**

A. L. Colton (?). Lick Observatory. 1895 Oct. 10^d 0^h 53^m 28^s G.M.T. *Age* 21^d 16^h. *Term.* + 7° 1 E. Refractor. *Ap.* 33 in. (0.838 m.). *F. L.* 570.2 in. (14.5 m.). *Exp.* 10 sec.

34. **Portion of Moon (Mare Serenitatis).**

A. L. Colton. Lick Observatory. 1895 Oct 7^d 21^h 17^m 18^s G.M.T. *Age* 19^d 12^h 14^m. *Term.* + 33° 4 E. Refractor. *Ap.* 33 in. (0.838 m.). *F. L.* 570.2 in. (14.5 m.). *Exp.* 8 sec.

R.A.S.
Ref.
No.

35. **Portion of Moon (Clavius, Maginus, Licetus, &c.).**
A. L. Colton. Lick Observatory. 1895 Oct. 8^d 23^h 13^m 14^s
G.M.T. Age 20^d 14^h. Term. + 14°·1 E. Refractor. Ap. 33 in.
(0·838 m.). F. L. 570·2 in. (14·5 m.). Exp. 10 sec.
36. **Portion of Moon (Stöfler, Regiomontanus, Albategnius, &c.).**
A. L. Colton (?). Lick Observatory. 1895 Oct. 8^d 23^h 9^m 10^s
G.M.T. Age 20^d 14^h. Term. + 14°·1 E. Refractor. Ap. 33 in.
(0·838 m.). F. L. 570·2 in. (14·5 m.). Exp. 10 sec.
37. **Portion of Moon (Tycho, Thebit, &c.).**
A. L. Colton (?). Lick Observatory. 1895 Oct. 10^d 0^h 55^m 30^s
G.M.T. Age 21^d 16^h. Term. + 1°·1 E. Refractor. Ap. 33 in.
(0·838 m.). F. L. 570·2 in. (14·5 m.). Exp. 10 sec.
38. **Portion of Moon (Theophilus, Mare Nectaris, &c.).**
A. L. Colton. Lick Observatory. 1895 Oct. 7^d 21^h 6^m 20^s G.M.T.
Age 19^d 12^h. Term. + 27°·4 E. Refractor. Ap. 33 in.
(0·838 m.). F. L. 570·2 in. (14·5 m.). Exp. 8 sec.
39. **Total Solar Eclipse, 1896 Aug. 9.**
S. Kostinsky. Novaya Zemlya. 1896 Aug. 9. Photographic
Telescope. Ap. 4 in. (0·102 m.). F.L. (). Exp.
3 sec.
40. **Total Solar Eclipse, 1896 Aug. 9.**
A. Hausky. Novaya Zemlya. 1896 Aug. 9. Ordinary Camera.
Ap. (). F. L. (). Exp. 26 sec.
41. **Cluster M. 56 Lyræ (N. G. C. 6779).**
George Dunn. Maidenhead. 1896 May 9. Position of Centre—
R.A. 9^h 11^m. Decl. + 29° 57'. Doublet (Portrait lens type). Ap.
15 in. (0·381 m.). F. L. 89·38 in. (2·27 m.). Exp. 100 min.
42. **Spiral Nebula M. 81, 82 Ursæ Majoris (N. G. C. 3031, 3034).**
George Dunn. Maidenhead. 1896 May 10. Position of Centre
—R.A. 9^h 46^m. Decl. + 69° 39'. Doublet (Portrait lens type).
Ap. 15 in. (0·381 m.). F. L. 89·38 in. (2·27 m.). Exp. 160 min.
43. **Cluster M 56 Lyræ (N. G. C. 6779), enlarged.**
George Dunn. Maidenhead. 1896 May 9. Position of Centre—
R.A. 9^h 11^m. Decl. + 29° 57'. Doublet (Portrait lens type).
Ap. 15 in. (0·381 m.). F. L. 89·38 in. (2·27 m.). Exp. 100 min.
44. **Total Solar Eclipse, 1871 Dec. 12.**
H. Davis (Lord Lindsay's expedition), Baikul, India. 1871 Dec. 12.
Dallmeyer Camera. Ap. 4 in. (0·102 m.). F. L. 33 in. (0·838 m.).
Exp. 15 sec.
45. **Total Solar Eclipse, 1875 Apr. 6.**
J. N. Lockyer and A. Schuster. Siam. 1875 Apr. 6. Small
Camera. Ap. (). F. L. 13 in. (0·330 m.).
Exp. 4 sec.
46. **Total Solar Eclipse, 1878 July 29.**
W. Harkness. Creston, Wyoming. 1878 July 29. Dallmeyer lens.
Ap. 6 in. (0·153 m.). F. L. 37·9 in. (0·963 m.). Exp. 60 sec.

R.A.S.
Ref.
No.47. **Total Solar Eclipse, 1882 May 17.**

W. Abney and A. Schuster. Assiut, Egypt. 1882 May 17.
Coronagraph. *Ap.* 4 in. (0'102 m.). *F. L.* 5 ft. 3 in. (1'60 m.).
Exp. 10 sec.

48. **Total Solar Eclipse, 1883 May 6.**

H. A. Lawrance and C. R. Woods, Caroline Island. 1883 May 6.
Corona Camera. *Ap.* 4 in. (0'102 m.). *F. L.* 66 in. (0'168 m.).
Exp.

49. **Total Solar Eclipse, 1885 Sept. 9.**

Mr. Radford. Wellington, New Zealand. 1885 Sept. 9.
Ap. (), *F. L.* ().
Exp. 2 sec.

50. **Total Solar Eclipse, 1886 Aug. 29.**

A. Schuster. Prickly Point, Grenada, West Indies. 1886 Aug. 29.
Coronagraph. *Ap.* 4 in. (0'102 m.). *F. L.* 5 ft. 3 in. (1'60 m.).
Exp. 20 sec.

51. **Total Solar Eclipse, 1887 Aug. 19.**

M. Sugiyama. Yomeiji—Yama, Japan. 1887 Aug. 19. Photo-
graphic telescope. *Ap.* 3'6 in. (0'091 m.). *F. L.* 4'6 ft. (1'40 m.).
Exp. 2 sec.

52. **Total Solar Eclipse, 1889 Jan. 1.**

W. H. Pickering. Willows, California. 1889 Jan. 1. Photo-
graphic telescope. *Ap.* 13 in. (0'33 m.). *F. L.* 16 ft. (4'88 m.).
Exp. 10 sec.

53. **Total Solar Eclipse, 1889 Dec. 22.**

J. M. Schaeberle (Lick Observatory Expedition). Cayenne. 1889
Dec. 22. Reflector. *Ap.* 18 in. (0'457 m.). *F. L.* 12 ft. (3'66 m.).
Exp. 5 sec.

54. **Total Solar Eclipse, 1893 Apr. 16.**

J. Kearney. Fundium, West Africa. 1893 Apr. 16. Dallmeyer
Photoheliograph. *Ap.* 4 in. (0'102 m.), with negative enlarging
lens. *Equiv. F. L.* 70 ft. (21'35 m.). *Exp.* 5 sec.

55. **Total Solar Eclipse, 1893 Apr. 16.**

A. Taylor. Pará-Curu, Brazil. 1893 Apr. 16. Dallmeyer lens.
Ap. 6½ in. (0'165 m.). *F. L.* 76 in. (1'93 m.). *Exp.* 2 sec.

56. **Great Nebula in Orion (N. G. C. 1976).**

W. E. Wilson. Daramona, Westmeath, Ireland. 1897 Jan. 23.
Position of Centre—R.A. 5^h 30^m. Decl. - 5° 27'. Silver-on-
glass Reflector. *Ap.* 2 ft. (0'61 m.). *F. L.* 10 ft. 6 in. (3'2 m.).
Exp. 40 min.

57. **Dumb-Bell Nebula in Vulpecula (N. G. C. 6853).**

W. E. Wilson. Daramona, Westmeath, Ireland. 1894 Aug. 6.
Position of Centre—R.A. 19^h 55^m. Decl. + 22° 25'. Silver-on-
glass Reflector. *Ap.* 2 ft. (0'61 m.). *F. L.* 10 ft. 6 in. (3'2 m.).
Exp. 20 min.

58. **Spiral Nebula in Canes Venatici (N. G. C. 5194-5).**

W. E. Wilson. Daramona, Westmeath, Ireland. 1897 Mar. 6.
Position of Centre—R.A. 13^h 24^m. Decl. + 47° 55'. Silver-on-
glass Reflector. *Ap.* 2 ft. (0'61 m.). *F. L.* 10 ft. 6 in. (3'2 m.).
Exp. 90 min.

R.A.S.
Ref.
No.

59. **Spiral Nebula in Canes Venatici (N. G. C. 5194-5). Enlarged.**
W. E. Wilson. Daramona, Westmeath, Ireland. 1897 Mar. 6.
Position of Centre—R.A. $13^h 24^m$. Decl. $+ 47^\circ 55'$. Silver-on-glass Reflector. *Ap.* 2 ft. (0'61 m.). *F. L.* 10 ft. 6 in. (3'2 m.).
Exp. 90 min.
60. **Annular Nebula in Lyra (N. G. C. 6720).**
W. E. Wilson. Daramona, Westmeath, Ireland. 1894 Sept. 9.
Position of Centre—R.A. $18^h 48^m$. Decl. $+ 32^\circ 51'$. Silver-on-glass Reflector. *Ap.* 2 ft. (0'61 m.). *F. L.* 10 ft. 6 in. (3'2 m.).
Exp. 20 min.
61. **Meteor Trail and Comet 1893 IV. (Brooks).**
E. E. Barnard. Lick Observatory. 1893 Nov. 13. *Position of Comet*—R.A. $13^h 8^m$. Decl. $+ 34^\circ$. Willard Lens. *Ap.* 6 in. (0'153 m.). *F. L.* 31 in. (0'787 m.). *Exp.* $2^h 5^m$.
62. **Total Solar Eclipse, 1898 Jan. 22.**
W. H. M. Christie. Sahdol, India. 1898 Jan. 22. Photographic telescope and Dallmeyer enlarging lens. *Ap.* 9 in. (0'229 m.).
F. L. 8 ft. 6 in. (2'59 m.). *Exp.* 5 sec.
63. **Total Solar Eclipse, 1898 Jan. 22.**
W. H. M. Christie. Sahdol, India. 1898 Jan. 22. Photographic telescope and Dallmeyer enlarging lens. *Ap.* 9 in. (0'229 m.).
F. L. 8 ft. 6 in. (2'59 m.). *Exp.* 20 sec.
64. **Total Solar Eclipse, 1896 Aug. 9.**
W. Shackleton (Sir G. Baden-Powell's Expedn.). Novaya Zemlya. 1896 Aug. 9. Coronagraph. *Ap.* $4\frac{1}{8}$ in. (0'118 m.). *F. L.* 6 ft. 9 in. (2'06 m.). *Exp.* 40 sec.
65. **Total Solar Eclipse, 1898 Jan. 22.**
E. H. Hills. Pulgaon, India. 1898 Jan. 22. Photoheliograph and Dallmeyer enlarging lens. *Ap.* 4 in. (0'102 m.). *F. L.* 5 ft. (1'525 m.). *Exp.* 12 sec.
66. **Nebula in Andromeda (N. G. C. 224).**
Royal Observatory, Greenwich. 1898 Sept. 23. *Position of Centre*—R.A. $0^h 36^m$. Decl. $+ 40^\circ 30'$. Refractor. *Ap.* 30 in. (0'762 m.). *F. L.* 11 ft. 5 in. (3'48 m.). *Exp.* 60 min.
67. **Spectrum of Sun's limb during Eclipse.**
E. H. Hills. Pulgaon, India. 1898 Jan. 22. A, at point of 2nd contact. B, at 3rd contact. C, Solar Spectrum. 2-prism flint spectroscope.
68. **Annular Nebula in Lyra (N. G. C. 6720).**
Lick Observatory. 1899 July 14. *Position of Nebula*—R.A. $18^h 48^m$. Decl. $+ 32^\circ 51'$. Crossley Reflector. *Ap.* 36 in. (0'915 m.).
F. L. 17 ft. 6 in. (5'33 m.). *Exp.* 10 min.
69. **Dumb-Bell Nebula in Vulpecula (N. G. C. 6853).**
Lick Observatory. 1899 July 31. *Position of Nebula*—R.A. $19^h 54^m$. Decl. $+ 22^\circ 20'$. Crossley Reflector. *Ap.* 36 in. (0'915 m.).
F. L. 17 ft. 6 in. (5'33 m.). *Exp.* 3 hours.
70. **Spiral Nebula in Canes Venatici (N. G. C. 5194-5).**
Lick Observatory. 1899 May 10. *Position of Nebula*—R.A. $13^h 24^m$. Decl. $+ 47^\circ 55'$. Crossley Reflector. *Ap.* 36 in. (0'915 m.). *F. L.* 17 ft. 6 in. (5'33 m.). *Exp.* 4 hours.

R.A.S.
Ref.
No.

71. **Spiral Nebula in Ursa Major (N. G. C. 5457).**
Lick Observatory. 1899 June 8. *Position of Nebula*—R.A. $13^h 58^m$.
Decl. $+ 55^\circ 1'$. Crossley Reflector. *Ap.* 36 in. (0.915 m.). *F. L.*
17 ft. 6 in. (5.33 m.). *Exp.* 4 hours.
72. **Trifid Nebula in Sagittarius (N. G. C. 6514).**
Lick Observatory. 1899 July 6. *Position of Nebula*—R.A. $17^h 54^m$.
Decl. $- 23^\circ 2'$. Crossley Reflector. *Ap.* 36 in. (0.915 m.). *F. L.*
17 ft. 6 in. (5.33 m.). *Exp.* 3 hours.
73. **Great Nebula in Orion (N. G. C. 1976).**
Lick Observatory. 1898 Dec. 11. *Position of Nebula*—R.A. $5^h 30^m$.
Decl. $- 5^\circ 27'$. Crossley Reflector. *Ap.* 36 in. (0.915 m.).
F. L. 17 ft. 6 in. (5.33 m.). *Exp.* 1 hour.
74. **Cluster M 13 Hereulis (N. G. C. 6205).**
Lick Observatory. 1899 July 13. *Position of Cluster*—R.A. 16^h
 37^m . Decl. $+ 36^\circ 44'$. Crossley Reflector. *Ap.* 36 in. (0.915 m.).
F. L. 17 ft. 6 in. (5.33 m.). *Exp.* 2 hours.
75. **Solar Surface with Faculæ.**
G. E. Hale. Kenwood Observatory, Chicago. 1893 Aug. 7. Spectro-
heliograph and 12-in. (0.305 m.) Refractor.
76. **Solar Surface with Faculæ and Prominences.**
G. E. Hale. Kenwood Observatory, Chicago. 1892 June 25.
Spectroheliograph and 12-in. (0.305 m.) Refractor.
77. **Total Solar Eclipse, 1898 Jan. 22.**
W. H. M. Christie. Sahdol, India. 1898 Jan. 22. Photographic
telescope and Dallmeyer enlarging lens. *Ap.* 9 in. (0.229 m.)
F. L. 8 ft. 6 in. (2.59 m.). *Exp.* $\frac{3}{8}$ sec.
78. **Nebula H V. 14 Cygni (N. G. C. 6992).**
W. E. Wilson. Daramona, Westmeath, Ireland. 1899 Oct.
Position of Nebula—R.A. $20^h 52^m$. Decl. $+ 31^\circ 16'$. Silver-on-
glass Reflector. *Ap.* 2 ft. (0.61 m.). *F. L.* 10 ft. 6 in. (3.2 m.).
Exp. 1 h. 30 m.
79. **Portion of Moon (Theophilus, Cyrillus, etc.).**
G. W. Ritchey. Yerkes Observatory. 1900 Oct. 12. *Age* about
19^d. *Term.* about 38° E. Visual Refractor and Colour Screen.
Ap. 40 in. (1.016 m.). *F. L.* 61 ft. (18.6 m.). *Exp.* $\frac{1}{2}$ sec.
80. **Total Solar Eclipse, 1900 May 28.**
E. E. Barnard. Wadesboro', North Carolina, 1900 May 28.
Horizontal Telescope (with celostat). *Ap.* 6 in. (0.153 m.).
F. L. 61½ ft. (18.753 m.). *Exp.* 30 sec.
81. **Comet 1901 I.**
Royal Observatory, Cape of Good Hope. 1901 May 4. *Position of*
Comet—R.A. $3^h 54^m$. Decl. $- 0^\circ 18'$. The Victoria (McClean)
Telescope. *Ap.* 24 in. (0.61 m.). *F. L.* 22½ ft. (6.86 m.). *Exp.*
15 min.
82. **Comet 1901 I.**
Royal Observatory, Cape of Good Hope. 1901 May 6. *Position of*
Comet—R.A. $4^h 19^m$. Decl. $+ 0^\circ 18'$. Portrait Lens. *Ap.*
(). *F. L.* (). *Exp.* 25 min.

R.A.S.
Ref.
No.

83. **Comet 1901 I.**

Perth Observatory, Western Australia. 1901 May 9. *Position of Comet*—R.A. $4^h 53^m$. Decl. $+ 1^\circ 32'$. Astrographic Refractor. *Ap.* 13 in. (0'33 m.). *F. L.* 11 ft. 4 in. (3'455 m.). *Exp.* 55 min.

84. **Solar Surface with Faculæ.**

H. Deslandres. Meudon. 1895 Aug. 18. Spectroheliograph. *Exp.* 3 min.

85. **Solar Prominences.**

H. Deslandres. Meudon. 1894 Apr. 11. Spectroheliograph. *Exp.* 3 min.

86. **Nebulosity about Nova Persei.**

G. W. Ritchey. Yerkes Observatory. 1901 Sept. 20. *Position of Nova*—R.A. $3^h 24^m$. Decl. $+ 43^\circ 34'$. Reflector. *Ap.* 2 ft. (0'61 m.). *F. L.* 93 in. (2'36 m.). *Exp.* 3 h. 50 m.

87. **Nebulosity about Nova Persei.**

G. W. Ritchey. Yerkes Observatory. 1901 Nov. 13. *Position of Nova*—R.A. $3^h 24^m$. Decl. $+ 43^\circ 34'$. Reflector. *Ap.* 2 ft. (0'61 m.). *F. L.* 93 in. (2'36 m.). *Exp.* 7 hours.

88. **Total Solar Eclipse, 1901 May 18.**

F. W. Dyson. Pulo Aoer Gadang, Sumatra. 1901 May 18. Thompson Photographic Telescope. *Ap.* 9 in. (0'229 m.). *F. L.* 36 ft. (10'97 m.). *Exp.* 10 sec.

89. **Total Solar Eclipse, 1901 May 18.**

F. W. Dyson. Pulo Aoer Gadang, Sumatra. 1901 May 18. Thompson Photographic Telescope. *Ap.* 9 in. (0'229 m.). *F. L.* 36 ft. (10'97 m.). *Exp.* 40 sec.

90. **Comet 1902 III. (Perrine).**

Royal Observatory, Greenwich. 1902 Sept. 29. *Position of Comet*—R.A. $0^h 13^m$. Decl. $+ 56^\circ 27'$. Reflector. *Ap.* 30 in. (0'762 m.). *F. L.* 11 ft. $4\frac{1}{2}$ in. (3'47 m.). *Exp.* 62 min.

91. **Portion of Moon (Mare Serenitatis to Mare Tranquillitatis).**

G. W. Ritchey and F. R. Sullivan. Yerkes Observatory. 1901 Aug. 3. *Age* about $18\frac{1}{2}^d$. *Term.* about 44° E. Visual Refractor and Colour Screen. *Ap.* 40 in. (1'016 m.). *F. L.* 61 ft. (18'6 m.). *Exp.* $\frac{1}{2}$ sec.

92. **Portion of Moon (Rough crater region above Mare Nubium).**

G. W. Ritchey and F. R. Sullivan. Yerkes Observatory. 1901 Nov. 21. *Age* about $10\frac{1}{2}^d$. *Term.* about $- 38^\circ$ M. Visual Refractor and Colour Screen. *Ap.* 40 in. (1'016 m.). *F. L.* 61 ft. (18'6 m.). *Exp.* 1 sec.

93. **Portion of Moon (Licetus to Theophilus).**

G. W. Ritchey and F. R. Sullivan. Yerkes Observatory. 1900 Oct. 12. *Age* about 19^d . *Term.* about 38° E. Visual Refractor and Colour Screen. *Ap.* 40 in. (1'016 m.). *F. L.* 61 ft. (18'6 m.). *Exp.* $\frac{1}{2}$ sec.

94. **Portion of Moon (Bullialdus to Copernicus).**

G. W. Ritchey and F. R. Sullivan. Yerkes Observatory. 1901 Nov. 20. *Age* $9^d 17\frac{1}{2}^h$. *Term.* $- 27^\circ 1$ M. Visual Refractor and Colour Screen. *Ap.* 40 in. (1'016 m.). *F. L.* 61 ft. (18'6 m.). *Exp.* 1 sec.

R.A.S.
Ref.
No.

95. **Portion of Moon (Copernicus).**
G. W. Ritchey and F. R. Sullivan. Yerkes Observatory. 1901 Nov. 20. Age $9^d 17\frac{1}{2}^h$. Term. $-27^{\circ} 1'$ M. Visual Refractor and Colour Screen. Ap. 40 in. (1'016 m.). F. L. 61 ft. (18'6 m.). Exp. 1 sec.
96. **Great Nebula in Orion (N. G. C. 1976).**
G. W. Ritchey and F. G. Pease. Yerkes Observatory. 1901 Oct. 19. Position of Nebula. R.A. $5^h 30'$. Decl. $-5^{\circ} 27'$. Reflector. Ap. 24 in. (0'61 m.). F. L. 93 in. (2'36 m.). Exp. 1 hour.
97. **Great Nebula in Orion (Central Portion).**
G. W. Ritchey and F. R. Sullivan. Yerkes Observatory. 1901 Jan. 20. Position of Nebula—R.A. $5^h 30^m$. Decl. $-5^{\circ} 27'$. Visual Refractor and Colour Screen. Ap. 40 in. (1'016 m.). F. L. 61 ft. (18'6 m.). Exp. 3 hours.
98. **Nebula in Andromeda (N. G. C. 224).**
G. W. Ritchey and F. G. Pease. Yerkes Observatory. 1901 Sept. 18. Position of Nebula—R.A. $0^h 36^m$. Decl. $+40^{\circ} 30'$. Visual Refractor and Colour Screen. Ap. 40 in. (1'016 m.). F. L. 61 ft. (18'6 m.). Exp. $4\frac{1}{2}$ hours.
99. **Nebula in Cygnus (N. G. C. 6960).**
G. W. Ritchey and F. G. Pease. Yerkes Observatory. 1902 Aug. 1. Position of Nebula—R.A. $20^h 40^m$. Decl. $+30^{\circ} 13'$. Reflector. Ap. 24 in. (0'61 m.). F. L. 93 in. (2'36 m.). Exp. 5 hours.
100. **Nebula in Cygnus (N. G. C. 6992).**
G. W. Ritchey and F. G. Pease. Yerkes Observatory. 1901 Oct. 5. Position of Nebula—R.A. $20^h 51^m$. Decl. $+31^{\circ} 10'$. Reflector. Ap. 24 in. (0'61 m.). F. L. 93 in. (2'36 m.). Exp. 3 hours.
101. **Cluster M. 13 Herculis (N. G. C. 6205).**
G. W. Ritchey and F. R. Sullivan. Yerkes Observatory. 1901 Apr. 25. Position of Cluster—R.A. $16^h 37^m$. Decl. $+36^{\circ} 44'$. Visual Refractor and Colour Screen. Ap. 40 in. (1'016 m.). F. L. 61 ft. (18'6 m.). Exp. 2 hours.
102. **Cluster M. 15 Pegasi (N. G. C. 7078).**
G. W. Ritchey and F. R. Sullivan. Yerkes Observatory. 1900 Oct. 3. Position of Cluster—R.A. $21^h 23^m$. Decl. $+11^{\circ} 31'$. Visual Refractor and Colour Screen. Ap. 40 in. (1'016 m.). F. L. 61 ft. (18'6 m.). Exp. 3 hours.
103. **Solar Surface, with Faculæ.**
G. E. Hale. Yerkes Observatory. 1903 Apr. 27. Spectroheliograph.
104. **The Moon, Age $5^d 23\frac{1}{2}^h$.**
P. Puiseux. Paris. 1900 Apr. $5^d 8^h$. Term. $+19^{\circ}$ M. Equatorial Coudé. Ap. 0'6 m. (23'62 in.). F. L. 18 m. (59 ft. 6'6 in.). Exp. 1'1 sec.
105. **The Moon, Age $13^d 5\frac{1}{2}^h$.**
P. Puiseux. Paris. 1902 Nov. $13^d 2^h 57^m$. Term. $-67^{\circ} 1'$ M. Equatorial Coudé. Ap. 0'6 m. (23'62 in.). F. L. 18 m. (59 ft. 6'6 in.). Exp. 0'6 sec.
106. **The Moon, Age $8^d 23\frac{1}{2}^h$.**
P. Puiseux. Paris. 1903 Feb. $6^d 4^h 3^m$. Term. $-21^{\circ} 7'$ M. Equatorial Coudé. Ap. 0'6 m. (23'62 in.). F. L. 18 m. (59 ft. 6'6 in.). Exp. 0'7 sec.

R.A.S.
Ref.
No.

107. **The Moon, Age 20^d 19^h.**
P. Puiseux. Paris. 1903 Sept. 12^d 3^h 13^m. Term. +9°·3 E.
Equatorial Coudé. Ap. 0·6 m. (23·62 in.). F. L. 18 m. (59 ft.
6·6 in.). Exp. 0·6 sec.
108. **Nebulosity about 15 Monocerotis.**
E. E. Barnard. Lick Observatory. 1894 Feb. 1. *Position of*
Centre—R.A. 6^h 35^m. Decl. +10°. Willard Lens. Ap. 6 in.
(0·153 m.). F. L. 31 in. (0·787 m.). Exp. 3 hours.
109. **Milky Way about β Cygni.**
E. E. Barnard. Lick Observatory. 1893 Oct. 12. *Position of*
Centre—R.A. 19^h 25^m. Decl. +26°. Willard Lens. Ap. 6 in.
(0·153 m.). F. L. 31 in. (0·787 m.). Exp. 5 h. 17 m.
110. **Nebulosity near α Cygni.**
E. E. Barnard. Lick Observatory. 1893 Oct. 5. *Position of*
Centre—R.A. 21^h 0^m. Decl. +42°. Willard Lens. Ap. 6 in.
(0·153 m.). F. L. 31 in. (0·787 m.). Exp. 6 h. 6 m.
111. **Milky Way near χ Cygni.**
E. E. Barnard. Lick Observatory. 1892 Oct. 20. *Position of*
Centre—R.A. 19^h 40^m. Decl. +33°. Willard Lens. Ap. 6 in.
(0·153 m.). F. L. 31 in. (0·787 m.). Exp. 5 hours.
112. **Star Cloud in Sagittarius.**
E. E. Barnard. Lick Observatory. 1892 June 20. *Position of*
Centre—R.A. 18^h 10^m. Decl. -20°. Willard Lens. Ap. 6 in.
(0·153 m.). F. L. 31 in. (0·787 m.). Exp. 4 h. 15 m.
113. **Milky Way in Cepheus.**
E. E. Barnard. Lick Observatory. 1893 Oct. 13. *Position of*
Centre—R.A. 21^h 35^m. Decl. +57°. Willard Lens. Ap. 6 in.
(0·153 m.). F. L. 31 in. (0·787 m.). Exp. 7 hours.
114. **Milky Way about M. 8 (N. G. C. 6523).**
E. E. Barnard. Lick Observatory. 1894 July 5. *Position of*
Centre—R.A. 17^h 55^m. Decl. -24° 23'. Willard Lens. Ap.
6 in. (0·153 m.). F. L. 31 in. (0·787 m.). Exp. 4 hours.
115. **Milky Way about θ Ophiuchi.**
E. E. Barnard. Lick Observatory. 1894 July 6. *Position of*
Centre—R.A. 17^h 15^m. Decl. -25°. Willard Lens. Ap. 6 in.
(0·153 m.). F. L. 31 in. (0·787 m.). Exp. 3 h. 35 m.
116. **Milky Way near N.G.C. 6475.**
E. E. Barnard. Lick Observatory. 1894 June 26. *Position of*
Centre—R.A. 17^h 45^m. Decl. -35°. Willard Lens. Ap. 6 in.
(0·153 m.). F. L. 31 in. (0·787 m.). Exp. 2 h. 50 m.
117. **Great Nebula near ρ Ophiuchi.**
E. E. Barnard. Lick Observatory. 1895 June 21-22. *Position of*
Centre—R.A. 16^h 20^m. Decl. -23°. Willard Lens. Ap. 6 in.
(0·153 m.). F. L. 31 in. (0·787 m.). Exp. 7 h. 30 m.
118. **Milky Way about 58 Ophiuchi.**
E. E. Barnard. Lick Observatory. 1895 June 26. *Position of*
Centre—R.A. 17^h 35^m. Decl. -22°. Willard Lens. Ap. 6 in.
(0·153 m.). F. L. 31 in. (0·787 m.). Exp. 4 h. 5 m.

R.A.S.
Ref.
No.

119. **Milky Way near Omega Nebula**
E. E. Barnard. Lick Observatory. 1895 July 25. *Position of Centre*—R.A. $18^{\text{h}} 30^{\text{m}}$. Decl. -15° . Willard Lens. *Ap.* 6 in. (0.153 m.). *F. L.* 31 in. (0.787 m.). *Exp.* 4 h. 25 m.
120. **Star Cloud in Sagittarius.**
E. E. Barnard. Lick Observatory. 1895 Aug. 13. *Position of Centre*—R.A. $17^{\text{h}} 56^{\text{m}}$. Decl. -28° . Willard Lens. *Ap.* 6 in. (0.153 m.). *F. L.* 31 in. (0.787 m.). *Exp.* 3 h. 5 m.
121. **Nebula about ν Scorpii.**
E. E. Barnard. Lick Observatory. 1895 May 23. *Position of Centre*—R.A. $16^{\text{h}} 5^{\text{m}}$. Decl. -19° . Willard Lens. *Ap.* 6 in. (0.153 m.). *F. L.* 31 in. (0.787 m.). *Exp.* 3 h. 20 m.
122. **The Sun.**
Royal Observatory, Greenwich. 1905 Jan. $30^{\text{d}} 12^{\text{h}} 8^{\text{m}} 27^{\text{s}}$ G.M.T. Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft. (2.75 m.). *Exp.* .
123. **Sun-Spot.**
Royal Observatory, Greenwich. 1905 Jan. $30^{\text{d}} 12^{\text{h}} 8^{\text{m}} 27^{\text{s}}$ G.M.T. Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft. (2.75 m.). *Exp.* .
124. **The Sun.**
Royal Observatory, Greenwich. 1905 Jan. $31^{\text{d}} 11^{\text{h}} 17^{\text{m}} 27^{\text{s}}$ G.M.T. Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft. (2.75 m.). *Exp.* .
125. **Sun-Spot.**
Royal Observatory, Greenwich. 1905 Jan. $31^{\text{d}} 11^{\text{h}} 17^{\text{m}} 27^{\text{s}}$ G.M.T. Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft. (2.75 m.). *Exp.* .
126. **The Sun.**
Royal Observatory, Greenwich. 1905 Feb. $2^{\text{d}} 10^{\text{h}} 50^{\text{m}} 28^{\text{s}}$ G.M.T. Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft. (2.75 m.). *Exp.* .
127. **Sun-Spot.**
Royal Observatory, Greenwich. 1905 Feb. $2^{\text{d}} 10^{\text{h}} 50^{\text{m}} 28^{\text{s}}$ G.M.T. Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft. (2.75 m.). *Exp.* .
128. **The Sun.**
Royal Observatory, Greenwich. 1905 Feb. $3^{\text{d}} 10^{\text{h}} 58^{\text{m}} 23^{\text{s}}$ G.M.T. Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft. (2.75 m.). *Exp.* .
129. **Sun-Spot.**
Royal Observatory, Greenwich. 1905 Feb. $3^{\text{d}} 10^{\text{h}} 58^{\text{m}} 23^{\text{s}}$ G.M.T. Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft. (2.75 m.). *Exp.* .
130. **The Sun.**
Royal Observatory, Greenwich. 1905 Feb. $5^{\text{d}} 12^{\text{h}} 13^{\text{m}} 22^{\text{s}}$ G.M.T. Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft. (2.75 m.). *Exp.* .
131. **Sun-Spot.**
Royal Observatory, Greenwich. 1905 Feb. $5^{\text{d}} 12^{\text{h}} 13^{\text{m}} 22^{\text{s}}$ G.M.T. Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft. (2.75 m.). *Exp.* .

R.A.S.
Ref.
No.

132. **The Sun.**

Royal Observatory, Greenwich. 1905 Feb. 8^d 13^h 3^m 5^s G.M.T.
Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft.
(2.75 m.). *Exp.* .

133. **Sun-Spot.**

Royal Observatory, Greenwich. 1905 Feb. 8^d 13^h 3^m 5^s G.M.T.
Thompson Photoheliograph. *Ap.* 9 in. (0.229 m.). *F. L.* 9 ft.
(2.75 m.). *Exp.* .

134. **Nebula near ψ Eridani.**

Max. Wolf. Königstuhl, Heidelberg. 1905 Jan. 8. *Position of*
Nebula—R.A. 4^h 59^m. Decl. -7° . Brashear Lens. *Ap.* 16 in.
(0.406 m.). *F. L.* . *Exp.* 4 h. 21 m.

135. **Nebula M. 33 Trianguli (N. G. C. 598).**

Isaac Roberts. Crowborough, Sussex. 1895 Nov. 14. *Position of*
Centre—R.A. 1^h 28^m. Decl. $+30^{\circ} 9'$. Reflector. *Ap.* 20 in.
(0.508 m.). *F. L.* 98 in. (2.49 m.). *Exp.* 2 h. 15 m.

136. **Nebula in Perseus (N. G. C. 1499).**

Isaac Roberts. Crowborough, Sussex. 1897 Dec. 18. *Position of*
Centre—R.A. 3^h 57^m. Decl. $+36^{\circ} 8'$. Reflector. *Ap.* 20 in.
(0.508 m.). *F. L.* 98 in. (2.49 m.). *Exp.* 90 min.

137. **Nebula in Monoceros (N. G. C. 2237-9).**

Isaac Roberts. Crowborough, Sussex. 1899 Mar. 5. *Position of*
Centre—R.A. 6^h 25^m. Decl. $+5^{\circ} 0'$. Reflector. *Ap.* 20 in.
(0.508 m.). *F. L.* 98 in. (2.49 m.). *Exp.* 2 h. 45 m.

138. **Nebula Π V 24 Comæ (N. G. C. 4565).**

Isaac Roberts. Crowborough, Sussex. 1896 May 11. *Position of*
Centre—R.A. 12^h 31^m. Decl. $+26^{\circ} 32'$. Reflector. *Ap.* 20 in.
(0.508 m.). *F. L.* 98 in. (2.49 m.). *Exp.* 2 h. 53 m.

139. **Nebula Π V 42 Comæ (N. G. C. 4631).**

Isaac Roberts. Crowborough, Sussex. 1894 Mar. 29. *Position of*
Centre—R.A. 12^h 38^m. Decl. $+32^{\circ} 56'$. Reflector. *Ap.* 20 in.
(0.508 m.). *F. L.* 98 in. (2.49 m.). *Exp.* 3 hours.

140. **Nebula Π V 37 Cygni (N. G. C. 7000 ?).**

Isaac Roberts. Crowborough, Sussex. 1896 Oct. 10. *Position of*
Centre—R.A. 20^h 55^m. Decl. $+43^{\circ} 56'$. Reflector. *Ap.* 20 in.
(0.508 m.). *F. L.* 98 in. (2.49 m.). *Exp.* 2 h. 55 m.

141. **Nebula Index Catalogue 405 Persei.**

Isaac Roberts. Crowborough, Sussex. 1902 Jan. 14. *Position of*
Centre—R.A. 5^h 9^m. Decl. $+34^{\circ} 13'$. Reflector. *Ap.* 20 in.
(0.508 m.). *F. L.* 98 in. (2.49 m.). *Exp.* 90 min.

142. **Clusters in Perseus (N. G. C. 869, 884).**

Isaac Roberts. Crowborough, Sussex. 1895 Oct. 12. *Position of*
Centre—R.A. 2^h 14^m. Decl. $+56^{\circ} 40'$. Reflector. *Ap.* 20 in.
(0.508 in.). *F. L.* 98 in. (2.49 m.). *Exp.* 90 min.

143. **Cluster Π VI 30 Cassiopeiæ (N. G. C. 7789).**

Isaac Roberts. Crowborough, Sussex. 1898 Dec. 17. *Position of*
Centre—R.A. 23^h 52^m. Decl. $+56^{\circ} 10'$. Reflector. *Ap.* 20 in.
(0.508 m.). *F. L.* 98 in. (2.49 m.). *Exp.* 90 min.

R.A.S.
Ref.
No.

144. **Total Solar Eclipse, 1905 Aug. 30.**
W. H. M. Christie. Sfax, Tunis. 1905 Aug. 30. Thompson
Coronagraph. *Ap.* 9 in. (0'229 m.). *F. L.* 36 ft. (10'97 m.).
Exp. 5 sec.
145. **Total Solar Eclipse, 1905 Aug. 30.**
W. H. M. Christie. Sfax, Tunis. 1905 Aug. 30. Thompson
Coronagraph. *Ap.* 9 in. (0'229 m.). *F. L.* 36 ft. (10'97 m.).
Exp. 20 sec.
146. **Total Solar Eclipse, 1905 Aug. 30.**
W. H. M. Christie. Sfax, Tunis. 1905 Aug. 30. Thompson
Coronagraph. *Ap.* 9 in. (0'229 m.). *F. L.* 36 ft. (10'97 m.).
Exp. 7 sec.
147. **Total Solar Eclipse, 1905 Aug. 30.**
W. H. M. Christie. Sfax, Tunis. 1905 Aug. 30. Astrographic
Telescope. *Ap.* 13 in. ('33 m.). *F. L.* 11 ft. 3 in. (3'43 m.).
Exp. 20 sec.
148. **Total Solar Eclipse, 1905 Aug. 30. (portion, showing large prominence).**
W. H. M. Christie. Sfax, Tunis. 1905 Aug. 30. Thompson
Coronagraph. *Ap.* 9 in. (0'229 m.). *F. L.* 36 ft. (10'97 m.).
Exp. 20 sec.
149. **Region of Nebula ρ Ophiuchi.**
E. E. Barnard. Mount Wilson Observatory. 1905 Apr. 5.
Position of Nebula—R.A. 16^h 20^m. Decl. - 23°. Bruce Photo-
graphic Doublet. *Ap.* 10 in. (0'254 m.). *F. L.* 50'3 in. (1'28 m.).
Exp. 4 h. 30 m.
150. **Nebula ρ Ophiuchi (enlarged).**
E. E. Barnard. Mount Wilson Observatory. 1905 Apr. 5.
Position of Nebula—R.A. 16^h 20^m. Decl. - 23°. Bruce Photo-
graphic Doublet. *Ap.* 10 in. (0'254 m.). *F. L.* 50'3 in. (1'28 m.).
Exp. 4 h. 30 m.
151. **Region of θ Ophiuchi.**
E. E. Barnard. Mount Wilson Observatory. 1905 June 5.
Position of Centre—R.A. 17^h 20^m. Decl. - 24°. Bruce Photo-
graphic Doublet. *Ap.* 10 in. (0'254 m.). *F. L.* 50'3 in. (1'28 m.).
Exp. 4 h. 40 m.
152. **Great Rift near θ Ophiuchi.**
E. E. Barnard. Mount Wilson Observatory. 1905 June 28.
Position of Centre—17^h 0^m. Decl. - 27°'5. Bruce Photographic
Doublet. *Ap.* 10 in. (0'254 m.). *F. L.* 50'3 in. (1'28 m.).
Exp. 4 h. 33 m.
153. **Great Star Cloud in Sagittarius.**
E. E. Barnard. Mount Wilson Observatory. 1905 June 29.
Position of Centre—R.A. 17^h 56^m. Decl. - 28°. Bruce Photo-
graphic Doublet. *Ap.* 10 in. (0'254 m.). *F. L.* 50'3 in. (1'28 m.).
Exp. 4 h. 53 m.
154. **Small Star Cloud in Sagittarius.**
E. E. Barnard. Mount Wilson Observatory. 1905 July 31.
Position of Dark Spot—R.A. 18^h 7^m. Decl. - 7°'5. Bruce
Photographic Doublet. *Ap.* 10 in. (0'254 m.). *F. L.* 50'3 in.
(1'28 m.). *Exp.* 4 h. 30 m.

R.A.S.
Ref.
No.

155. **Region of Cluster M. 11 (N.G.C. 6705).**

E. E. Barnard. Mount Wilson Observatory. 1905 July 30.
Position of Centre—R.A. $18^h 45^m$. Decl. $-7^{\circ}5'$. Bruce Photographic Doublet. *Ap.* 10 in. (0.254 m.). *F. L.* 50.3 in. (1.28 m.).
Exp. 5 h. 30 m.

156. **Sun-Spots.**

Royal Observatory, Greenwich. 1906 July 6^d 16^h 32^m 4^s G.M.T.
Thompson Photographic Refractor. *Ap.* 26 in. (0.66 m.).
F. L. 22.5 ft. (6.86 m.). *Exp.*

157. **Sun-Spot.**

Royal Observatory, Greenwich. 1906 July 31^d 16^h 32^m 4^s G.M.T.
Thompson Photographic Refractor. *Ap.* 26 in. (0.66 m.).
F. L. 22.5 ft. (6.86 m.). *Exp.*

158. **Sun-Spot.**

Royal Observatory, Greenwich. 1906 Aug. 3^d 17^h 10^m 0^s G.M.T.
Thompson Photographic Refractor. *Ap.* 26 in. (0.66 m.). *F. L.*
22.5 ft. (6.86 m.). *Exp.*

159. **Total Solar Eclipse, 1905 Aug. 30 (portion showing large prominence).**

De la Baume Pluvinel. Alcala de Chisvert, Spain. 1905 Aug. 30.
Horizontal Refractor and Cœlostet. *Ap.* 0.153 m. (6 in.).
F. L. 11.880 m. (38 ft. 11 $\frac{3}{4}$ in.). *Exp.* 2 sec.

160. **Comet 1908 III. (Morehouse).**

P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Sept. 7^d 14^h 56^m G.M.T. *Position of Comet*—R.A. 3^h 3^m.
Decl. $+69^{\circ}38'$. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 60 min.

161. **Comet 1908 III. (Morehouse).**

P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Sept. 14^d 8^h 22^m G.M.T. *Position of Comet*—R.A. 2^h 11^m.
Decl. $+73^{\circ}40'$. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 20 min.

162. **Comet 1908 III. (Morehouse).**

P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Sept. 29^d 13^h 12^m G.M.T. *Position of Comet*—R.A. 21^h 41^m.
Decl. $+73^{\circ}29'$. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 50 min.

163. **Comet 1908 III. (Morehouse).**

P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Sept. 29^d 14^h 13^m G.M.T. *Position of Comet*—R.A. 21^h 41^m.
Decl. $+73^{\circ}29'$. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 15 min.

164. **Comet 1908 III. (Morehouse).**

P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Sept. 29^d 15^h 19^m G.M.T. *Position of Comet*—R.A. 21^h 41^m.
Decl. $+73^{\circ}29'$. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 50 min.

165. **Comet 1908 III. (Morehouse).**

P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Sept. 29^d 16^h 15^m G.M.T. *Position of Comet*—R.A. 21^h 41^m.
Decl. $+73^{\circ}29'$. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 25 min.

R.A.S.
Ref.
No.

166. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Oct. 3^d 9^h 4^m G.M.T. *Position of Comet*—R.A. 20^h 44^m.
Decl. + 68° 58'. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 30 min.
167. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Oct. 3^d 13^h 13^m G.M.T. *Position of Comet*—R.A. 20^h 44^m.
Decl. + 68° 58'. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 38 min.
168. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Oct. 27^d 10^h 2^m G.M.T. *Position of Comet*—R.A. 19^h 2^m.
Decl. + 29° 43'. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 20 min.
169. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Oct. 29^d 7^h 3^m G.M.T. *Position of Comet*—R.A. 19^h 0^m.
Decl. + 26° 48'. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 20 min.
170. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Oct. 30^d 7^h 47^m G.M.T. *Position of Comet*—R.A. 18^h 59^m.
Decl. + 25° 18'. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 10 min.
171. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Nov. 3^d 6^h 43^m G.M.T. *Position of Comet*—R.A. 18^h 56^m.
Decl. + 19° 41'. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 10 min.
172. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Oct. 1^d 8^h 55^m G.M.T. *Position of Comet*—R.A. 21^h 10^m.
Decl. + 71° 29'. Portrait Lens. *Ap.* 3.5 in. (0.89 m.). *F. L.* 11 in.
(0.28 m.). *Exp.* 80 min.
173. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Oct. 30^d 6^h 56^m G.M.T. *Position of Comet*—R.A. 18^h 59^m.
Decl. + 25° 18'. Portrait Lens. *Ap.* 3.5 in. (0.89 m.). *F. L.* 11 in.
(0.28 m.). *Exp.* 40 m.
174. **Comet 1908 III. (Morehouse).**
E. E. Barnard. Yerkes Observatory. 1908 Sept. 30^d 20^h 57^m
G.M.T. *Position of Comet*—R.A. 21^h. Decl. + 72°. Bruce
Doublet Lens. *Ap.* 6 in. (0.153 m.). *F. L.* 50.3 in. (1.28 m.).
Exp. 47 min.
175. **Comet 1908 III. (Morehouse).**
E. E. Barnard. Yerkes Observatory. 1908 Oct. 1^d 14^h 45^m G.M.T.
Position of Comet—R.A. 21^h. Decl. + 71°. Bruce Doublet Lens.
Ap. 6 in. (0.153 m.). *F. L.* 50.3 in. (1.28 m.). *Exp.* 50 min.
176. **Comet 1908 III. (Morehouse).**
E. E. Barnard. Yerkes Observatory. 1908 Oct. 1^d 19^h 15^m G.M.T.
Position of Comet—R.A. 21^h. Decl. + 71°. Bruce Doublet Lens.
Ap. 6 in. (0.153 m.). *F. L.* 50.3 in. (1.28 m.). *Exp.* 65 min.

R.A.S.
Ref.
No.

177. **Comet 1908 III. (Morehouse).**
E. E. Barnard. Yerkes Observatory. 1908 Oct. 15^d 12^h 57^m
G.M.T. *Position of Comet*—R.A. 19^h 27^m. Decl. + 50° 16'.
Bruce Doublet Lens. *Ap.* 10 in. (0.254 m.). *F. L.* 50.3 in.
(1.28 m.). *Exp.* 82 min.
178. **Solar Surface showing Sun-Spot Vortices.**
G. E. Hale and F. Ellerman. Mount Wilson Observatory. 1908
Oct. 7^d 15^h 2^m G.M.T. Snow Telescope and 5 ft. Spectroheliograph. Slit 0.075 m. wide, set on Hydrogen line (H α).
179. **Total Solar Eelipse, 1908 Jan. 3.**
Croker (Lick Observatory) Expedition. Flint Island, South Pacific.
1908 Jan. 3. Camera. *Ap.* 5 in. (0.127 m.). *F. L.* 40 ft.
(12.2 m.). *Exp.* 16 sec.
180. **Comet 1908 III. (Morehouse).**
E. E. Barnard. Yerkes Observatory. 1908 Oct. 16^d 15^h 32^m
G.M.T. *Position of Comet*—R.A. 19^h 23^m. Decl. + 47° 48'.
Bruce Doublet Lens. *Ap.* 10 in. (0.254 m.). *F. L.* 50.3 in.
(1.28 m.). *Exp.* 2 h. 15 m.
181. **Comet 1908 III. (Morehouse).**
E. E. Barnard. Yerkes Observatory. 1908 Nov. 16^d 13^h 10^m
G.M.T. *Position of Comet*—R.A. 18^h 52^m. Decl. + 5° 5'.
Bruce Doublet Lens. *Ap.* 10 in. (0.254 m.). *F. L.* 50.3 in.
(1.28 m.). *Exp.* 1 h. 3 m.
182. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Nov. 19^d 6^h 4^m G.M.T. *Position of Comet*—R.A. 18^h 51^m.
Decl. + 2° 20'. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 30 min.
183. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Nov. 22^d 5^h 55^m G.M.T. *Position of Comet*—R.A. 18^h 51^m.
Decl. - 0° 9'. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 20 min.
184. **Comet 1908 III. (Morehouse).**
P. J. Melotte and C. R. Davidson. Royal Observatory, Greenwich.
1908 Nov. 25^d 5^h 55^m G.M.T. *Position of Comet*—R.A. 18^h 51^m.
Decl. - 2° 30'. Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 11 ft.
5 in. (3.48 m.). *Exp.* 15 min.
185. **Stellar Spectra, Secchi's Types I., II., and III.**
Stonyhurst College Observatory. Type I., α Aquilæ. Type II.,
 β Geminorum. Type III., β Pegasi.
186. **Progressive Stella Spectra between Secchi's Type III. and Type II.**
Stonyhurst College Observatory. α Ceti, α Herculis, β Pegasi,
 η Geminorum, α Orionis, β Andromedæ, and α Tauri.
187. **Spectrum of γ Cassiopeiæ.**
Stonyhurst College Observatory.
188. **Spectra of α Ceti.**
Stonyhurst College Observatory. 1897 Nov. 29 and 1906 Dec. 1, 14.

R.A.S.
Ref.
No.

189. **Spectra of α Ceti and α Herculis.**
Stonyhurst College Observatory. 1897 Dec. and 1898 Feb.
190. **Spectra of β Aurigæ.**
Stonyhurst College Observatory. 1906 Feb. 4, 11.
191. **Spectra of Nova Persei and Castor.**
Stonyhurst College Observatory. 1901 Feb. 28 and 1901 Feb. 19.
192. **Alternating Spectra, Nova Persei.**
Stonyhurst College Observatory. 1901 Mar. 21-28.
193. **Titanium Oxide flutings in α Ceti.**
A. Fowler, Royal College of Science, South Kensington.
194. **Comet 1908 III. (Morehouse); Stereogram.**
E. E. Barnard. Yerkes Observatory. 1908 Oct. 15. No. 1, 12^h 58^m. No. 2, 14^h 31^m. G.M.T. Bruce Doublet Lens. *Ap.* 10 in. (0.254 m.). *F. L.* 50.3 in. (1.28 m.).
195. **Comet 1908 III. (Morehouse); Stereogram.**
E. E. Barnard. Yerkes Observatory. 1908 Nov. 16. No. 1, 12^h 14^m. No. 2, 13^h 46^m. G.M.T. Bruce Doublet Lens. *Ap.* 10 in. (0.254 m.). *F. L.* 50.3 in. (1.28 m.).
196. **Comet 1908 III. (Morehouse); Stereogram.**
E. E. Barnard. Yerkes Observatory. 1908 Nov. 18. Bruce Doublet Lens. *Ap.* 10 in. (0.254 m.). *F. L.* 50.3 in. (1.28 m.).
197. **Mars.**
G. E. Hale. Mount Wilson Observatory. 1909 Oct. 5. Reflector (arranged in Cassegrain form) and red screen. *Ap.* 60 in. (1.524 m.). *Equiv. F. L.* 100 ft. (30.48 m.). *Exp.* about 2 sec.
198. **Mars.**
G. E. Hale. Mount Wilson Observatory. 1909 Nov. 3. Reflector (arranged in Cassegrain form) and red screen. *Ap.* 60 in. (1.524 m.). *Equiv. F. L.* 100 ft. (30.48 m.). *Exp.* about 2 sec.
199. **Spectra of Moon and Major Planets.**
V. M. Slipher. Lowell Observatory. Moon, Jupiter, Saturn, Uranus, and Neptune.
200. **4-Prism Spectrograph of the Newall Telescope.**
H. F. Newall. Cambridge Observatory.
201. **Spectra of High and Low Sun.**
G. Higgs. Liverpool. No. 1, High Sun. No. 2, Low Sun, showing atmospheric absorption lines.
202. **Spectrum of α Persei.**
H. F. Newall. Cambridge Observatory. 1902 Sept. 19. 4-prism Spectrograph and Newall Telescope. *Comparison Spectrum*—Iron.
203. **Spectra of Earliest Stars.**
William Huggins. Tulse Hill. β Lyræ, Bellatrix and Rigel. *Comparison spectra*—Sun, Helium, Oxygen and Nitrogen.
204. **Spectra of Early Stars.**
William Huggins. Tulse Hill. Rigel, α Cygni, α Leonis, γ Lyræ, γ Andromedæ and α Lyræ. *Comparison Spectra*—Sun, Helium, Silicium and Titanium.

R. A. S.
Ref.
No.

205. **Spectra of Early Solar Stars.**
William Huggins. Tulse Hill. Sirius, Castor (fainter star), α Aquilæ, Procyon and γ Cygni. *Comparison Spectrum*—Sun.
206. **Spectra of Pre-Solar Stars.**
William Huggins. Tulse Hill. α Leonis, γ Lyræ, α Lyræ, Sirius, Castor (fainter star) and α Aquilæ. *Comparison Spectrum*—Sun.
207. **Spectra of Solar and Post Solar Stars.**
William Huggins. Tulse Hill. γ Cygni, α Aurigæ (Capella), α Boötis (Arcturus), γ Andromedæ (yellow star), and α Orionis (Betelgeuse). *Comparison Spectra*—Sun, Iron and Calcium.
208. **Spectra of Double Stars.**
William Huggins. Tulse Hill. Castor (brighter star), Castor (fainter star), γ Andromedæ (blue star and yellow star) and β Cygni (blue star and yellow star). *Comparison Spectrum*—Sun.
209. **Stellar Spectra, Secchi's Types III. and IV.**
G. E. Hale. Mount Wilson Observatory. 74, 132, 152 and 229 Schj., α Orionis and μ Geminorum. *Comparison Spectrum*—Carbon.
210. **Stellar Spectra, Secchi's Type IV. (Blue Region).**
G. E. Hale. Mount Wilson Observatory. 74, 78, 132, 152 and 280 Schj., 19 Pisc. and 318 Birm.
211. **Stellar Spectra, Secchi's Type IV. (Yellow and Green Regions).**
G. E. Hale. Mount Wilson Observatory. 74, 78, 115, 132, 152, 280 and 1556 Schj., 19 Pisc. and 318 Birm.
212. **Stellar Spectra, Secchi's Types II., III., and IV. (Blue Region).**
G. E. Hale. Mount Wilson Observatory. Sun, 74 and 280 Schj. and μ Geminorum.
213. **Spectra of Iron, Titanium and Chromium.**
C. P. Butler. Solar Physics Observatory, South Kensington. Spark and Arc Spectra.
214. **Portion of Moon (South Pole to Hipparchus).**
G. E. Hale. Mount Wilson Observatory. 1909 Oct. 5. *Age* about $20\frac{1}{2}^d$. *Term.* about + 20 E. Reflector (arranged in Cassegrain form). *Ap.* 60 in. (1'524 m.). *Equiv. F. L.* 100 ft. (30'48 m.). *Exp.* about 1 sec.
215. **Portion of Moon (North Pole to Agrippa).**
G. E. Hale. Mount Wilson Observatory. 1909 Oct. 5. *Age* about $20\frac{1}{2}^d$. *Term.* about + 20 E. Reflector (arranged in Cassegrain form). *Ap.* 60 in. (1'524 m.). *Equiv. F. L.* 100 ft. (30'48 m.). *Exp.* about 1 sec.
216. **Comet 1910 I. (Daylight).**
V. M. Slipher. Lowell Observatory. 1910 Jan. 27. *Position of Comet*—R. A. $21^h 24^m$. Dec. — $1^\circ 8'$.
217. **Halley's Comet.**
H. Knox Shaw. Helwân Observatory. 1910 Mar. $4^d 5^h 9^m$ G. M. T. *Position of Comet*—R. A. $0^h 31^m$. Decl. + $7^\circ 55'$. Reynolds Reflector. *Ap.* 30 in. (0'762 m.). *F. L.* 135 in. (3'43 m.). *Exp.* 25 min.

R.A.S.
Ref.
No.

218. **Halley's Comet.**

H. Knox Shaw. Helwân Observatory. 1910 Apr. 16^d 14^h 25^m
G.M.T. *Position of Comet*—R.A. 23^h 54^m. Decl. + 7° 49'.
Reynolds Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 135 in. (3.43 m.).
Exp. 5 min.

219. **Halley's Comet.**

H. Knox Shaw. Helwân Observatory. 1910 Apr. 27^d 14^h 7^m
G.M.T. *Position of Comet*—R.A. 23^h 50^m. Decl. + 7° 55'.
Reynolds Reflector. *Ap.* 30 in. (0.762 m.). *F. L.* 135 in.
(3.43 m.). *Exp.* 5 min.

220. **Halley's Comet.**

E. E. Barnard. Yerkes Observatory. 1910 May 4. *Position of Comet*—R.A. 0^h 5^m. Decl. + 9° 12'. Bruce Doublet Lens.
Ap. 6 in. (0.153 m.). *F. L.* 50.3 in. (1.28 m.).

221. **Great Nebula in Orion (N. G. C. 1976); Central Portion.**

G. W. Ritchey. Mount Wilson Observatory. 1909 Sept. 16.
Position of Nebula—R.A. 5^h 30^m. Decl. - 5° 27'. Reflector.
Ap. 60 in. (1.524 m.). *F. L.* 299 in. (7.6 m.). *Exp.* 45 min.

222. **Nebula in Andromeda (N. G. C. 224); Central Portion.**

G. W. Ritchey. Mount Wilson Observatory. 1909 Oct. 13.
Position of Nebula—R.A. 0^h 36^m. Decl. + 40° 30'. Reflector.
Ap. 60 in. (1.524 m.). *F. L.* 299 in. (7.6 m.). *Exp.* 2 hours.

223. **Spiral Nebula, Canes Venatici (N. G. C. 5194-5).**

G. W. Ritchey. Mount Wilson Observatory. 1910 Feb. 7 and 8.
Position of Nebula—R.A. 13^h 24^m. Decl. + 47° 55'. Reflector.
Ap. 60 in. (1.524 m.). *F. L.* 299 in. (7.6 m.). *Exp.* 3 h. 55 m.

224. **Spiral Nebula, M. 101 Ursæ Majoris (N. G. C. 5457).**

G. W. Ritchey. Mount Wilson Observatory. 1910 Mar. 10 and 11.
Position of Nebula—R.A. 13^h 58^m. Decl. + 55° 1'. Reflector.
Ap. 60 in. (1.524 m.). *F. L.* 299 in. (7.6 m.). *Exp.* 7 h. 30 m.

225. **Spiral Nebula M. 81 Ursæ Majoris (N. G. C. 3031).**

G. W. Ritchey. Mount Wilson Observatory. 1910 Feb. 5.
Position of Nebula—R.A. 9^h 44^m. Decl. + 69° 43'. Reflector.
Ap. 60 in. (1.524 m.). *F. L.* 299 in. (7.6 m.). *Exp.* 4 h. 15 m.

226. **Cluster M. 3 Can. Venat. (N. G. C. 5272).**

G. W. Ritchey. Mount Wilson Observatory. 1910 Apr. 9.
Position of Cluster—R.A. 13^h 36^m. Decl. + 29°. Reflector.
Ap. 60 in. (1.524 m.). *F. L.* 299 in. (7.6 m.). *Exp.* 3 h. 30 m.

227. **Annular Nebula in Lyra (N. G. C. 6720).**

G. W. Ritchey. Mount Wilson Observatory. 1909 Sept. 17.
Position of Nebula—R.A. 18^h 48^m. Decl. + 32° 51'. Reflector.
Ap. 60 in. (1.524 m.). *F. L.* 299 in. (7.6 m.). *Exp.* 30 min.

228. **Crab Nebula in Taurus (N. G. C. 1952).**

G. W. Ritchey. Mount Wilson Observatory. 1909 Oct. 13.
Position of Nebula—R.A. 5^h 26^m. Decl. + 21° 55'. Reflector.
Ap. 60 in. (1.524 m.). *F. L.* 299 in. (7.6 m.). *Exp.* 3 hours.

229. **Owl Nebula in Ursa Major (N. G. C. 3587).**

G. W. Ritchey. Mount Wilson Observatory. 1910 Feb. 9.
Position of Nebula—R.A. 11^h 7^m. Decl. + 55° 47'. Reflector.
Ap. 60 in. (1.524 m.). *F. L.* 299 in. (7.6 m.). *Exp.* 4 hours.

R.A.S.
Ref.
No.

230. **Nebula H. V. 24 Comæ Berenicis (N. G. C. 4565).**
G. W. Ritchey. Mount Wilson Observatory. 1910 Mar. 6-7.
Position of Nebula—R.A. $12^{\text{h}} 31^{\text{m}}$. Decl. $+ 26^{\circ} 32'$. Reflector.
Ap. 60 in. (1'524 m.). *F. L.* 299 in. (7'6 m.). *Exp.* 5 hours.
231. **Spiral Nebula M. 33 Trianguli (N. G. C. 598).**
G. W. Ritchey. Mount Wilson Observatory. 1910 Aug. 5-7.
Position of Nebula—R.A. $1^{\text{h}} 28^{\text{m}}$. Decl. $+ 30^{\circ} 9'$. Reflector.
Ap. 60 in. (1'524 m.). *F. L.* 299 in. (7'6 m.). *Exp.* 8 h. 30 m.
232. **Spiral Nebula M. 64 Comæ Berenicis (N. G. C. 4828).**
G. W. Ritchey. Mount Wilson Observatory. 1910 May 5-8.
Position of Nebula—R.A. $12^{\text{h}} 50^{\text{m}}$. Decl. $+ 28^{\circ} 47'$. Reflector.
Ap. 60 in. (1'524 m.). *F. L.* 299 in. (7'6 m.). *Exp.* 7 h. 56 m.
233. **Nebula in Cygnus (N. G. C. 6960).**
G. W. Ritchey. Mount Wilson Observatory. 1910 July 4 and 5.
Position of Nebula—R.A. $20^{\text{h}} 40^{\text{m}}$. Decl. $+ 30^{\circ} 7'$. Reflector.
Ap. 60 in. (1'524 m.). *F. L.* 299 in. (7'6 m.). *Exp.* 6 h. 30 m.
234. **Nebula in Cygnus (N. G. C. 6992).**
G. W. Ritchey. Mount Wilson Observatory. 1910 July 2-4.
Position of Nebula—R.A. $20^{\text{h}} 52^{\text{m}}$. Decl. $+ 31^{\circ} 16'$. Reflector.
Ap. 60 in. (1'524 m.). *F. L.* 299 in. (7'6 m.). *Exp.* 10 h. 15 m.

Nos. 44-55, Nos. 64, 65, and No. 147 form a series of corona photographs, oriented and reduced to the same scale.

The above photographs (excepting Nos. 194-196) are now on sale to Fellows as prints, either platinotype or aristotype, mounted on sunk cut-out mounts, measuring 12 inches by 10 inches; also unmounted, and as lantern slides. Nos. 44-55 and Nos. 64 and 65 are also supplied as transparencies, $6\frac{1}{4}$ inches square.

Price of prints, mounted 1s. 6d. each, unmounted 1s. each; lantern slides, 1s. each; packing and postage extra.

Transparencies, $6\frac{1}{4}$ inches square (Nos. 44-55 and Nos. 64 and 65), 3s. 6d. each.

Nos. 194-196 are for the stereoscope, and are not supplied as lantern slides. Transparencies, 2s. each; mounted aristotype prints, 1s. each.

Orders to be addressed to W. H. Wesley, Burlington House, London, W. In ordering prints or slides the R.A.S. Reference No. only need be quoted, but in the case of prints it should be stated whether platinotypes or aristotypes are required, and whether mounted or unmounted.

The Award of the Gold Medal.

The Council have awarded the Society's Gold Medal to Mr. A. R. Hinks for his determination of the Solar Parallax from observations of Eros. The President will lay before the Society the grounds upon which the award has been founded.

Publications of the Society.

During the past year vol. lxxi. of the *Monthly Notices* has been issued.

The following parts of the *Memoirs* have also been published :—

Vol. lx. part i. S. A. Saunder. The determination of Selenographic positions and the measurement of lunar photographs.

Vol. lx. part ii. Bryan Cookson. A research on the Aberration Constant and the Variation of Latitude by means of a Floating Zenith Telescope.

OBITUARY.

The Council regret that they have to record the loss by death of the following Fellows, Associate, and Honorary Member during the past year:—

Fellows:—Algernon Sidney Bicknell.

James Cavan.

Lord Edward Spencer-Churchill.

William Coleman.

Arthur Cottam.

S. Maitland Baird Gemmill.

Benjamin George Jenkins.

Louis Stromeyer Little.

William Thynne Lynn.

James Oddie.

Rev. James Dunne Parker.

Emanuel Joseph Ristori.

Herbert Shaw.

John Samuel Slater.

George Johnstone Stoney.

Lieut.-Col. George Strahan.

François Joseph Charles Terby.

John Watson.

Francis Richard Wegg-Prosser.

Associate:—Jean Charles Rodolphe Radau.

Honorary Member:—Williamina P. Fleming.

ALGERNON SIDNEY BICKNELL, son of the late Mr Elhanan Bicknell, of Herne Hill, a well-known collector of pictures, was born on 1832 October 9. Possessed of independent means, he followed no profession, but devoted himself to travel, to Alpine climbing, and to an extensive acquaintance with many branches of science. At Staplefield Place, Sussex, where he lived for many years, he possessed a well-equipped observatory, though he contributed no observations to the Society. At one time he held a commission in the Militia. He was a liveryman and sometime master of the Vintners' Company.

Mr. Bicknell married in 1857 Rosa, daughter of the late Mr. Wild, of London, who, with two sons and four daughters, survives him. He died at Brighton, after an operation, on 1911 October 26.

He was elected a Fellow of the Society on 1890 January 10.

JAMES CAVAN was the only son of the late Lieut.-Colonel Philip Charles Cavan, 30th Regiment, and was born at Portland Place, London, on 1856 September 29. He was educated at Harrow and Christ Church, Oxford.

Throughout his life Mr. Cavan was keenly interested in astronomy and in the construction of instruments. At his country seat at Eaton Mascott Hall, Shrewsbury, he built a well-equipped private observatory, with a $7\frac{1}{2}$ -inch photo-visual by Cooke & Sons, a transit instrument, and large chronograph with control of his own design.

He devoted much time to the public business of the county of Shropshire, was a member for six years of the County Council, chairman of the Salop Infirmary, and for two years president of the West Shropshire Conservative Association.

He married, on 1886 August 25, Amy Mabel, daughter of W. H. Patterson, Esq., of Garranard, Co. Down, and leaves a son and two daughters. He died at Eaton Mascott on 1911 April 25.

He was elected a Fellow of the Society on 1896 March 13.

LORD EDWARD SPENCER CHURCHILL, youngest son of the sixth Duke of Marlborough by his third marriage, was born on 1853 March 28. He was educated at Eton and at Magdalene College, Cambridge. He held a commission for nine years in the Isle of Wight Artillery Militia, and was a Deputy Lieutenant for the county of Worcester. He was keenly interested in astronomy, electricity, and microscopy.

He married in 1874 September, Augusta, daughter of the late Major G. D. Warburton, M.P., who survives him, with one son and two daughters. He died in London after a short illness on 1911 May 5.

He was elected a Fellow on 1891 December 11, but contributed no papers to the Society.

WILLIAM COLEMAN was born 1824 January 4 in the parish of St. Mary, Dover. He was the owner of Solton Manor, about four miles from Dover, and he occupied his leisure in superintending this estate until failing health led him to dispose of it shortly before his death on April 9, 1911. Mr. Coleman had a strong interest in astronomy, and was for many years an active observer and a regular attendant at the meetings of the Society. He erected at his residence, The Shrubbery, Buckland, near Dover, an observatory, provided with an equatorial telescope of 8-in. aperture, by Messrs. Cooke & Sons, and devoted himself especially to the measurement of double stars. His first contribution to the publications of the Society was a paper printed in vol. liii. of the *Memoirs*, containing his double star measures made in the years 1893-1896. The list included 161 pairs, and of some of these long series of measures were given. A similar paper dealing with the measures of 131 pairs made by him in the years 1897-1899 was published in vol. liv. of the *Memoirs*. Mr. Coleman was a

most conscientious observer, and spared no pains to secure accuracy in his results. The stars dealt with by him were well selected, and included many pairs of which no recent measures existed.

By his will Mr. Coleman gave power to his executors to offer his observatory, telescope, and accessories to the Royal Astronomical Society, by whom they were gratefully accepted; the instruments have been lent to the Rev. Theodore E. R. Phillips, who has re-erected them at Ashted, Surrey.

Mr. Coleman was elected a Fellow of the Society 1884 February 8.

ARTHUR COTTAM was born at Camberwell on 1836 April 9. At the age of fifteen, his father having died the year before, he entered the office of Woods and Forests, where he remained till he retired when nearly sixty years of age. The routine of a Government office was not what he would have chosen, and every leisure moment was devoted by him to scientific and artistic pursuits; he thus accomplished a large amount of interesting and valuable work.

Mr. Cottam's talents were many and varied. He was an accomplished artist and musician; and his scientific interest included astronomy, microscopy, entomology, and botany. It was one of his characteristics to spare no pains in bringing his work to the highest state of perfection of which it was capable, and the delicacy of his manipulation is evidenced by the exquisite mounting and arrangement of his various collections. In microscopical slide mounting he had few rivals. He was one of the oldest members of the Quekett Microscopical Club, was recognised by the members as one of the authorities on Fossil Diatomaceæ, and was a constant exhibitor at their meetings. He was also one of the founders and the first Hon. Treasurer of the Hertfordshire Natural History Society, whilst he was living in Watford, where he resided for thirty-seven years.

One of Mr. Cottam's closest friends was the late Mr. N. E. Green, like himself an artist as well as an astronomer. Both men took a leading part in the formation of the British Astronomical Association. Mr. Cottam was one of the original joint secretaries, his department being the work connected with the observing sections. He held this office for two years, and the thoroughness with which he carried out his duties had much to do with the good start made by the Association on this side. He took a very warm interest in the Jupiter section, and zealously supported Mr. Waugh, its first director, in his work. He himself directed the section during the apparition of 1900, and compiled the memoir of that year's observations.

Star charting was the astronomical work to which he devoted the most attention, and here his skill in draughtsmanship enabled him to produce very beautiful results.

His "Charts of the Constellations from the North Pole to between 35 and 40 degrees of South Declination" are well known.

It was his intention to supplement these by a similar set of charts of the South Polar Constellations, but this work he never completed.

Mr. Cottam used two telescopes in his observations, a $4\frac{1}{2}$ -inch refractor by Merz, and a 12-inch reflector. He acquired the latter instrument from Mr. N. E. Green, who had it constructed to his own design for the purposes of his observations of Mars in 1877.

In 1860 Mr. Cottam married Mary Gibbs, of Kingsbury, who survives him, and he lived to celebrate their golden wedding a year before his death. They had one son and two daughters, of whom only the younger daughter is now living. His son died in March last, unexpectedly, after an operation, and there is no doubt that the shock of this loss hastened his own death, which occurred 1911 November 23, at Bridgwater, where he had lived since 1905.

He was elected a Fellow 1862 February 14.

LOUIS STROMEYER LITTLE was the third son of the late Dr. W. J. Little, physician to the London Hospital, and was born in London on 1840 November 23. He was educated at St. Paul's School, in Germany at Hanover and Kiel, and at University College, London, where he studied under De Morgan. After taking the degree of Bachelor of Arts at London University, he became an articled pupil at the Royal College of Surgeons, and took the diploma of M.R.C.S. in 1862, proceeding to the F.R.C.S. in 1866. In 1862 he was appointed assistant surgeon to the London Hospital, and soon became known as an original and skilful operator. In 1864 he was attached to a field hospital during the Schleswig-Holstein campaign, and in 1866 he took an active part in dealing with the epidemic of cholera in the east of London.

In 1869 he was appointed to the charge of the Shanghai General Hospital, and in Shanghai he built a small observatory, where, in the midst of his arduous professional duties, he found time to do interesting astronomical work. In collaboration with some officers of the fleet he determined the longitude of Shanghai by exchange of telegraphic signals with Nagasaki; this was the first telegraphic longitude determined in China. An account of the work is published in the *M.N.*, vol. xli. pp. 64 and 415. On 1881 November 8 he observed the transit of Mercury (*M.N.* xlii. p. 104).

In 1899 he resigned his position in China, and returning to England *via* South Africa saw further war service with No. 9 hospital at Bloemfontein during the Boer war; but after three months his health failed and he came home.

He died on 1911 October 4, at Whitehill, Bletchingly, Surrey, leaving a widow and one son.

He was elected a Fellow of the Society on 1877 January 12.

WILLIAM THYNNE LYNN was born in London on 1835 August 9. His father, William Bewicke Lynn, had served as

an army surgeon and was attached to the 5th Fusiliers in the Peninsular war, but at the time of the birth of his son William held the post of senior surgeon at Westminster Hospital. Mr. Lynn's early days were spent in the country at the village of Claygate, near Esher, in Surrey, where his family lived after his father's retirement from practice. He was at first educated at home, and afterwards at King's College, London, of which he became an associate. He always showed a strong leaning towards the study of natural phenomena, but astronomy especially attracted him, and in his nineteenth year he obtained a post as supernumerary computer at the Royal Observatory, Greenwich. A year later he became assistant at the Cambridge University Observatory, but after eighteen months returned to Greenwich, where he was appointed assistant in 1856 September. In 1859 he became superintendent of supernumerary computers; but though he was now responsible for the work connected with the publication of the annual Greenwich volume, he nevertheless managed to make time for private study, and obtained the degree of B.A. at London University in 1861. In 1871 he was placed in charge of the Altazimuth, and became a first-class assistant in 1874, but unfortunately his health began to give way, and for this reason he retired from the Observatory Staff in January 1880.

During his connection with the Royal Observatory he communicated to the Society a number of papers dealing chiefly with the proper motions of certain stars, including Procyon, Groombridge 1830, Arcturus, and others.

In Mr. Lynn's case retirement from official work afforded the opportunity for a kind of research for which his knowledge of classical literature and of the French and German languages specially fitted him, and which he prosecuted with conspicuous success. While deeply interested to the last in modern astronomical problems and investigations, he became an exceptionally diligent and accurate student of astronomy on its historical and antiquarian side. He was often to be found at the British Museum and the library of the Society, and his studies enabled him to bring to light a host of interesting details connected with the personal history and work of past astronomers, with which he enriched the pages of various periodicals devoted to scientific matters. He was a prolific writer on topics of this kind, and was also the author of several small books dealing with more ordinary subjects. His *Celestial Motions* was the basis of a larger work by Professor D. P. Todd entitled *Stars and Telescopes*, and his little books *Remarkable Eclipses* and *Remarkable Comets* are well known and have passed through many editions. Ancient chronological and biblical matters also interested him deeply, and he published small books on these subjects.

In 1900 Mr. Lynn joined the British Astronomical Association, and was a member of the Council during several years and at the time of his death. He took an active part in the work of the Association; and during his eleven and a half years of membership

contributed a very large number of papers and notes, his last being read at the November meeting, less than a fortnight before his death.

Mr. Lynn possessed a good memory and a keen sense of humour, and his mind was well stored with interesting reminiscences of former days. He died on the night of 1911 December 11, after a few hours' illness. His familiar figure will be much missed at meetings of the Society and of the British Astronomical Association, and especially by those who enjoyed the privilege of his personal friendship.

He was elected a Fellow of the Society 1862 February 14.

T. E. R. P.

JAMES ODDIE, son of James and Margaret Oddie, was born at Clitheroe on 1824 March 31. After a somewhat slight education, partly at a school held in a blacksmith's shop, he started life as assistant to a tinsmith, and was soon afterwards employed as a foundryman and journeyman moulder. For some time he was employed at the foundry of Nasmyth's engineering works, and remembered seeing the early trials of the steam hammer. Then he went to London, and worked in shipbuilding yards on the Thames; was for some time employed at Rotterdam; and thence moved to the railway works of the Great Western Railway.

Mr. Oddie sailed for Australia on the ship *Larpen*, and in 1849 June he landed at Geelong as one of the "forty-niners"; he lived to take part in the celebrations of the sixtieth anniversary of the landing. He found himself in Ballarat on the day after the first discovery of gold, and it is said that his imprudence in admitting to a journalist that he was winning thirty ounces of gold a day led to the great rush to the field. From that time Mr. Oddie lived at Ballarat, and was closely identified with every form of public enterprise in the rapidly growing city, devoting his time and fortune in particular to the foundation of an Art Gallery and the equipment of the Mount Pleasant Observatory. The observatory has been purchased by the School of Mines, but some of the best instruments he presented to the Federal Government for the proposed Federal Observatory.

Mr. Oddie was twice married, but no children survive him. He died on 1911 March 3, at the age of eighty-seven, the last survivor in Ballarat of the days of the gold discoveries.

He was elected a Fellow of the Society on 1889 November 8.

EMANUEL JOSEPH RISTORI was born in Rome in 1857. His father, Henry Ristori, was one of the pioneers of railway enterprise in Italy. The Marchesa del Grillo, better known as Adelaida Ristori, the famous tragic actress, was his aunt. Ristori studied engineering in the University of Rome, but took his degree of Doctor of Philosophy in that of Naples in 1881. For a short time he was Assistant Astronomer in the Observatory of the Roman College and in the Royal Observatory of Naples. In 1882

he migrated to London and was engaged with Nordenfelt, and later with the Maxim-Nordenfelt Company, in the manufacture of guns and explosives. Later on he was associated with Alfred Nobel, the inventor of dynamite, in working out and developing smokeless powder. He next turned his attention to metallurgy, and about 1890 founded the British Aluminium Company, of which he was for some years chief engineer and managing director. He was the pioneer in this country of the use of water power on a large scale, which rendered possible the profitable manufacture of aluminium. In 1908 he was instrumental in founding the Institute of Metals, and he was a Member of Council of that body until his death. He was the author of the article on Aluminium in the *Encyclopædia Britannica*, and contributed many papers to various professional publications on metallurgy and explosives, in which subjects he was admitted to be an authority.

He died on 1911 May 21, leaving a widow and one daughter.

He was elected a Fellow of the Society 1883 May 11.

HERBERT SHAW was born at Greenfield, near Oldham, on 1870 December 5. He was always an earnest student of science, but it was not until 1899 that he had an opportunity of entering upon a scientific career. In that year a Government studentship secured his admission to the Royal College of Science at South Kensington, and in due course he gained the associateship of the College in the division of physics. During three years Mr. Shaw was a student-assistant in the department of astrophysics, under Sir Norman Lockyer, and took part also in the work of the Solar Physics Observatory. In 1905 he was appointed demonstrator of astrophysics under Professor Fowler, and held this post until his death, which occurred with painful suddenness on 1911 December 15. Mr. Shaw's extensive knowledge and inexhaustible patience combined to make him an admirable teacher, and his efforts were always highly appreciated by the students with whom he had to deal. He was an extremely careful computer and experimentalist, and took an active part in the research work of the spectroscopic laboratory. He communicated no papers to the Society, but some of his work on spectral series, and on the spectrum of vanadium, was published in the *Astrophysical Journal*. At the time of his death, a paper on the spectrum of cyanogen, of which he was joint author, was in course of publication in the *Proceedings of the Royal Society*.

He was elected a Fellow of the Society in 1908 March 13.

A. F.

JOHN SAMUEL SLATER was the third son of the late Rev. Samuel Slater, D.D., Rector of Stenigot, Lincoln, and sometime Headmaster of Bishop Cotton School, Simla. He was born in Calcutta in 1850, educated at Pocklington Grammar School, Yorks, and Bishop Cotton School, Simla. He graduated in 1870 at the Thomason Civil Engineering College, Rurki, obtaining the gold

medal for mathematics. The same year he was appointed to the Public Works Department of the Government of India and served at Dera Ghazi Khan and other places in the Punjab.

In 1875 he was appointed Professor of Engineering at the Presidency College, Calcutta, and in 1880, when the Engineering Department of that College was formed into an independent residential Engineering College at Sibpur, he took a leading part in its organisation, became one of the original members of its staff, and was eventually appointed Principal in 1891.

He inaugurated a scheme of modern education for the District Schools of Bengal and Assam, and was responsible for the reorganisation of the technical schools of those two provinces. In 1897 he was for some months Inspector of Schools of the Rajshahi Division, and in 1901 officiated as head of the Educational Department of Bengal; in 1904 he was incapacitated by a serious illness which necessitated his retirement from India.

Mr. Slater was responsible for teaching astronomy to the students of the Engineering College, and was always keenly interested in that science. In 1891, while on leave, he devised and patented an Armillary Sphere, which has proved of value for instructional purposes.

After his retirement he devoted himself enthusiastically to an investigation of the pollen of plants, and prepared by microphotography a very large number of enlarged photographs of pollen grains; the value of his work in this direction was recognised by the botanical authorities at Kew.

He married in 1873 Jessie Frances, only daughter of Surgeon Major John Bean attached to the Royal Irish Fusiliers, by whom he had a son, deceased, and a daughter, who is married to Mr. B. Heaton, the present Principal of the Sibpur Engineering College.

He died at Ealing on 1911 April 7, aged 61.

He was elected a Fellow of the Society on 1892 January 8.

GEORGE JOHNSTONE STONEY was the elder son and third child of the late George Stoney, of Oakley Park, King's Co., and his wife Anne, daughter of Bindon Blood, Esq., of Cranagher and Rockforrest, Co. Clare. He was born in Ireland on 1826 February 15, and was educated at Trinity College, Dublin, where he took high honours in mathematics.

On the completion of his studies at Trinity College he became assistant to Lord Rosse at Parsonstown, where he took a share in the work of the six-foot reflector, and made many of the observations of nebulae which were published in the various Memoirs issued from that observatory.

He spent altogether two years and a half with Lord Rosse, from 1848 July to 1850 August, and from 1852 August to December of that year.

In 1852 he was appointed Professor of Natural Philosophy at University College, Galway, where he did excellent work for five

years, until his appointment to the office of Secretary to the Queen's University, and his consequent removal to Dublin.

From 1857 to 1893 Dr. Johnstone Stoney played an active part in the scientific life of Dublin. For twenty years he was an Honorary Secretary of the Royal Dublin Society, greatly occupied in its many-sided activities, which include the world-famous Horse Show. During this period he published many of his most notable researches, of which we may mention in particular his memoir "On the Physical Constitution of the Sun and Stars" (*Proc. R.D.S.*, 1868), the starting-point of his long series of researches on the laws of gaseous atmospheres and the escape of the lighter gases at their upper limits.

In the concluding memoir of this series (*Scientific Transactions of the R. Dublin Society*, vi. 305) he explains the absence of hydrogen and helium from the Earth's atmosphere, and the absence of all known constituents of an atmosphere from the Moon; and he further arrives at the conclusion that the vapour of water cannot exist in the atmospheres of either Mercury or Mars. This investigation also offers an explanation of such gaps in the series of chemical elements as we find upon the Earth between hydrogen and helium, and between helium and lithium; and it shows that if the suspected intermediate elements exist, the conditions upon Jupiter are such that they may all be present in his atmosphere, and that some of them may be present upon the other major planets, though not upon any of the four inner planets to which the Earth belongs.

This important paper was reprinted in *Ap. J.*, vol. vii. p. 25. Dr. Stoney's conclusions were criticised in a paper by Mr. S. R. Cook (*Ap. J.*, vol. viii. p. 36), on the ground that no determination had been made of the number of molecules which would escape, and that the application of Maxwell's law of the distribution of velocities suggested that the number thus actually escaping would be infinitesimal. In the same volume of the *Ap. J.*, Dr. Stoney replied with two papers giving reasons why he considered the Maxwell laws inapplicable to the case, and Professor Bryan then joined issue with him. The long and very profound controversy which ensued ranged over the pages of the *Astrophysical Journal*, *Proceedings of the Royal Society*, *British Association Reports*, *Philosophical Magazine*, and *Nature*, and it is not possible to summarise the wealth of argument with which Dr. Stoney held his ground. But a study of his contributions to the discussion exhibit in the most favourable way the long reflection and profound thought which he gave to any problem in which he became interested.

Two other ideas which we owe to Dr. Stoney are of particular interest to astronomers. He first made the suggestion that the bright clouds of the Sun's photosphere are composed of incandescent carbon; and he introduced the notion of the "electron" within the molecule, which has come to be of prime importance in the theory of radiation. On 1899 Mar. 22 the Boyle Medal of the Royal

Dublin Society was awarded to Dr. Stoney, and in the report of the Committee which recommended the award, his theory of the electron is thus referred to:—

“The bold realisation of events, which we are accustomed to associate with the vast cycles of astronomy, as occurring in orbits too minute and during periods too transient for the mind to grasp, is characteristic of the writer.

“The recent and powerful method of research with which the work of Lorentz and of Zeeman has armed physicists is every day rendering acknowledgment to this beautiful theory of Dr. Stoney’s.”

In 1893 Dr. Stoney removed to London, and since that date he contributed important papers to the Society, of which we may mention, “On the Equipment of the Astrophysical Observatory of the future” (*Monthly Notices*, lvi. 452), “Inquiry as to the Cause of the Shadow Bands upon the Earth which accompany Total Eclipses of the Sun” (*Monthly Notices*, lx. 586), and “Examination of Mr. Whittaker’s Undulatory Explanation of Gravity from the Physical Standpoint.” The first of these contains interesting suggestions on a method of supporting large specula on a flexible diaphragm behind which air is maintained at a pressure automatically controlled to balance the normal component of the weight of the speculum; and an elegant plan for the improvement of the Foucault siderostat, by substituting for the usual sliding sleeve a rectilinear motion obtained from a point on the circumference of a circle rolling inside another of twice the diameter. Models of these devices were exhibited to the Society. The *Monthly Notices* also contain parts of the work which he undertook, in conjunction with Dr. Downing, on the perturbations of the Leonids; the principal paper was published in *Proc. R.S.*, lxiv. 403. His last published work was an extensive inquiry into the theory of Telescopic Vision (*Phil. Mag.*, Series VI.), vol. xvi., 1908.

Dr. Stoney was elected a Fellow of the Royal Society on 1861 June 6, and the degree of Sc.D. was conferred on him by the University of Dublin.

Dr. Stoney married his cousin, Margaret Stoney, and leaves two sons and three daughters. He died in London on 1911 July 5.

He was elected a Fellow of the Society on 1860 February 10.

GEORGE STRAHAN, the son of William Strahan, was born at Ashurst in Surrey in 1839. He was educated at Eton, and in 1857 he entered the Military College of the Honourable East India Company at Addiscombe. He obtained his commission in the Bengal Engineers in 1858, following the footsteps of his elder brother Charles, who rose to be Surveyor-General of India. He went to India in 1860, and was first posted to the Bengal Sappers and Miners at Roorkee, subsequently joining the Irrigation Branch of the Public Works Department. He was employed on the Ganges Canal for fifteen months, and in July 1862 was appointed to the Survey of India. In this he remained for his whole

working life, retiring in 1894 from the post of Deputy Surveyor-General, having during his thirty-two years' service contributed in no small measure to the development of that great organisation. For many years he was engaged in topographical surveys. The mapping of India, on what may be described as modern principles, had just been started at the time when Strahan joined the Service. His indefatigable industry, his lightning rapidity of work, and, it may be added, his skilful and artistic draughtsmanship soon rendered him an invaluable member of the Survey staff. It would be tedious to recount here the details of the strenuous years he spent on this congenial work. In 1862 he was in Central India, in 1864 in Rajputana, and in 1866-7 he made the first contoured survey which had ever been made of any part of the Himalaya Mountains, at the proposed cantonment of Pokri.

The Rajputana Survey employed him, with intermissions, until 1875, when he was transferred to Mysore. One of these intermissions was due to the transit of Venus of 1874 December, which he observed at Lahore with a six-inch refractor, combined with an extensive series of transit instrument observations for time and longitude.

He was in charge of the Mysore Survey from 1875 to 1881, and it may be noted that the Committee which sat on the Indian Survey in 1905, while condemning many of the maps of India, stated that "Mysore is more fortunate in its maps than any other province of India. . . . The maps . . . could hardly be improved."

In 1881 Strahan entered upon a new period of his career, being transferred from the topographical to the geodetic branch. There he was first engaged upon longitude work, then upon a survey of the Nicobar Islands, carried out with his usual rapidity and efficiency in the face of great difficulties, then some more longitudes and azimuths, and in 1888 he succeeded General Haig as Deputy Surveyor-General in charge of the Trigonometrical Survey. Administrative work and the careful patience required to discuss and classify geodetic observations were not so well suited to Strahan's temperament as the busy activity of the field operations of a survey. He was essentially a man of action, one who would rather work himself than see others working, and to whom it was impossible to stand by and look on. He was not naturally in sympathy with the meticulous accuracy necessary in the primary work of a geodetic survey, and his early training had imbued him with ideas which were foreign to the traditions of the trigonometrical branch. At the same time, while often disapproving of what he considered a search for an unreasonable degree of precision, no one could have been more strict in maintaining the traditional accuracy of the work. Whatever may have been his personal opinions, he relaxed no rule of his predecessors, and when he retired from the Service in 1894 it was with the sincere regrets of his colleagues, who were poorer for the loss of his infectious enthusiasm. He was an ingenious inventor, and was continually devising new methods

and instruments, many of which have survived. He was an artist of no mean merit, and his renderings of the beauties of Indian scenery, while doubtless full of technical faults—for the conditions of his life precluded his getting any real artistic training,—have an extraordinary power of moving the spectator and are deservedly popular with the Anglo-Indian public. After his retirement he returned to India for the eclipse of 1898 January 22.

He communicated to the Society some sketches of the Great Comet (1882 *b*) and a note on the meteor shower of 1885 November 27. He went to Vadsö with the party on the *Norse King* to observe the eclipse of 1896 August 9.

He died at Hampstead on 1911 January 7, at the age of 71, leaving a widow, two sons, and two daughters.

He was elected a Fellow on 1869 March 12.

E. H. H.

FRANÇOIS JOSEPH CHARLES TERBY was born at Louvain on 1846 August 8. He was the son of François Pierre Terby, who was Professor of Music at the Academy of Louvain. He received his early education at the Collège de Josephites at Louvain, subsequently pursuing his studies under private instruction. After taking degrees at the University in philosophy and letters, and as doctor in natural sciences, he devoted several years to teaching as examiner in physics at the University of Louvain, professor of natural science and physics at the Collège Communal, and professor of physics, chemistry, and mechanics at the École Industrielle in that city.

Terby at an early period devoted himself to astronomy. His first communication to the Belgian Academy was in 1866, but prior to this, in 1864, he had commenced the study of the planet Mars which he pursued with so much assiduity throughout his life. It was the publication in 1873 of his memoir on the *Areographische Fragmente* of Schroeter, which had remained in manuscript since 1816, that first brought Terby prominently to the notice of astronomers; and this was followed the next year by an elaborate memoir entitled *Areographie*, in which he very fully discussed all the observations of the physical appearance of Mars from the time of Fontana in 1636 to the year 1873. This important memoir was accompanied by drawings of several unpublished observations and formed a very complete résumé of our knowledge of the appearance of Mars up to that date.

Terby showed great activity as an observer, working at first with a 3½-inch telescope by Secretan, and from 1885 with an 8-inch equatorial by Grubb. He made numerous observations of the planets, accompanied by drawings, which were communicated mainly to the Belgian Academy. Indeed, he accomplished a very great amount of observational work, for his communications to academies and various astronomical publications fall in number little short of two hundred. His observations were made with great care and conscientiousness, and they form collectively a very valuable contribution to astronomy. For many years before his death, which

took place on 1911 March 20, the state of his health compelled him to give up all astronomical observation. His labours were recognised by the Royal Academy of Belgium, who elected him a correspondent in 1889, and member in 1891.

In 1896 he was nominated by the Government Chevalier of the Order of Leopold, of which he became Officer in 1907. From its institution he was a member of the Committee of the Royal Observatory of Belgium.

He was a member of the British Astronomical Association, of the Liverpool Astronomical Society, the Astronomical Society of Toronto, the Italian Spectroscopic Society, and honorary member of the Société Scientifique Flammarion of Marseilles.

He was elected a Fellow of this Society 1874 November 13.

E. B. K.

JOHN WATSON was born at Broughty Ferry, on the east coast of Scotland, on 1844 October 20. His education was begun in the village school, and continued at the Dundee High School. His father was a friend of Dr. Dick, whose astronomical writings in the first half of last century were well known. It was through Dr. Dick's telescope that Mr. Watson, when quite a boy, had his first view of the moon. He very early developed a taste for mathematics, and in 1858 Donati's comet drew his attention to astronomy. His first telescope, which he purchased when a youth, was a three-inch refractor of excellent quality, with which he never parted; though it was superseded by a five-inch Grubb, equatorially mounted and clock driven by Dalmeyer.

A mechanical engineer by profession, his calling necessitated much travel, and gained for him wide experience. He visited India, Egypt, and the Holy Land, and spent two years in the Australian Colonies. He resided also some time in Vienna and in Lodz. In this way he visited a number of observatories, and enjoyed the friendship of many astronomers. He interested himself also in the work of the N.W. Branch of the British Astronomical Association and assisted in the establishment of the West of Scotland Branch in Glasgow. At the time of his death he was a past President of the Manchester Astronomical Society, and Vice-President of the Liverpool Society. He was chief engineer in the ironworks of Messrs. Pearson Knowles Coal & Iron Company of Warrington, where he was held in the highest esteem.

He died at St. Anne's-on-the-Sea on 1911 July 16.

He was elected a Fellow of the Society on 1897 January 8.

R. K.

FRANCIS RICHARD WEGG-PROSSER, son of the Reverend Francis Haggitt, D.D., was born on 1824 June 19 at the Rectory, Nuneham Courtenay, Oxon., of which parish his father was rector. He was educated at Eton and Balliol College, Oxford. On the death of his uncle, the Venerable Archdeacon R. Prosser, D.D., he inherited the estate of Belmont, Hereford,

and took the name of Wegg-Prosser. He represented Herefordshire in Parliament from 1847 to 1852; was Deputy Lieutenant and a Justice of the Peace for the County; and served the office of High-Sheriff in 1855.

He married in 1850 Lady Harriet Catherine Somers-Cocks, daughter of the second Earl Somers.

Mr. Wegg-Prosser wrote many articles on astronomical subjects in the *Dublin Review* and the *Month*, and was also the author of two books, *Galileo and his Judges* and *Rome and her Captors*.

He died on 1911 August 16, at Merry Hill House, Belmont.

He was elected a Fellow of the Society on 1875 June 11.

JEAN CHARLES RODOLPHE RADAU was born at Angerburg in East Prussia on 1835 January 22; his father was Director of an asylum for the deaf and dumb. He was educated in the secondary school of his native town, and afterwards at the Gymnasium "Kneiphof" at Königsberg. He was a student at the Albertus-Universität at that city, first in mathematics and afterwards in astronomy, and in 1855-56 he was a volunteer observer at the Observatory of Königsberg. At that time he wrote his first memoir, which contained some of the earliest applications of the elliptic functions to the problem of three bodies. It was published in 1864 in the *Mondes* of the Abbé Moigno. In 1857 he undertook the reduction of the observations of the traveller Antoine d'Abbadie, and it was this collaboration which took him to Paris, where he passed the rest of his life, with the exception of a period during the Franco-German war.

In Paris he became a scientific journalist, and in 1866 he obtained a position on the staff of the *Revue des deux Mondes*; he soon became editorial secretary, and for forty years was largely responsible for the direction of this celebrated review. While thus occupied he found time to carry on his mathematical investigations, so that in 1871 he was given the degree of Doctor of Philosophy *honoris causa* by the Albertus-Universität in recognition of his mathematical eminence.

Returning to Paris after the war, he became associated with Darboux in the production of the *Bulletin des Sciences Mathématiques*, and later was one of the founders of the *Bulletin Astronomique*, to which he contributed a great number of notices and reviews.

The Academy of Sciences had proposed as the subject for the Prix Damoiseau for 1892 the planetary perturbations in the motion of the Moon, of which at that time the theory was very little developed. Radau gained the prize with a memoir of which it is impossible to speak too highly. Nine-tenths of his work was on entirely fresh ground, and it was done so thoroughly that later investigators have been able to do little more than obtain insignificant corrections to it.

This work marked him as the natural successor to Tisserand in the Academy, to which he was elected in 1897. Two years later

he became a member of the Bureau des Longitudes, and from that time he devoted himself to the task of completing the Tables of the Moon on the theory of Delaunay. These tables had been projected for a long time, and had occupied the attention of Tisserand, but the difficulties connected with the planetary inequalities had prevented any considerable progress. These difficulties being removed by the work of Radau himself, he was able to make such good progress that they were completed and printed, with a full and most useful introduction, in the summer of last year. They will be adopted at once in the *Connaissance des Temps*, and the comparison of their predictions with those to be founded on the forthcoming tables of Brown will be of the highest interest.

The name of Radau will be associated in particular with these developments of the lunar theory, but in a summary of his contributions to astronomy we must not omit to notice his other works in celestial dynamics, in the theory of the figure of the Earth, and especially in the theory of refraction. His two long memoirs on this last subject, published in the *Memoirs of the Paris Observatory*, vols. xvi. and xix., contain an elaborate comparison of the various existing theories with the law of decrease of temperature as observed in balloons. This led him to adopt the hypothesis of Ivory, as most nearly accordant with observation; and he has developed the results of his theory in an elaborate set of tables which include the effects of humidity.

On the completion of the lunar tables the health of M. Radau began to fail, but he was able to occupy himself as usual with the editing of the *Bulletin Astronomique* until a few days before his death, which occurred almost suddenly on 1911 December 21.

At his funeral on 1911 December 29 three discourses were pronounced: by M. Henri Deslandres in the name of the Academy, by M. Bigourdan in the name of the Bureau des Longitudes, and by M. Henri Poincaré in the name of the Conseil de l'Observatoire. From the last we may be permitted to extract this tribute to the character of our distinguished Associate:—

“Radau vivait très isolé, et ses dernières années auraient pu sembler désespérément tristes, s'il n'avait eu une consolation, une joie, la seule qu'il eût jamais recherchée, celle de pouvoir travailler jusqu'au bout.

“Il aimait le travail, et il l'aimait pour lui-même; ce qu'il y cherchait, ce n'étaient pas les honneurs qui en sont parfois la récompense; certes non, ceux qui ont assisté à ses diverses candidatures savent combien de mal ont eu ses amis à le décider à briguer des places qu'il avait cent fois méritées; ils savent qu'on n'a pu triompher de ces répugnances qu'en lui prouvant que ces places avaient besoin de lui. Ce n'étaient pas non plus la gloire que ses découvertes scientifiques pouvait faire jaillir sur son nom; nul n'était plus étranger à une pareille vanité, peu lui importait d'être célèbre après sa mort, pourvu qu'il fût utile pendant sa vie.

"Non, ce qu'il cherchait dans le travail, c'était peut-être un peu le plaisir de poursuivre la vérité et de la trouver, mais c'était avant tout le bonheur de travailler; tel un alpiniste qui entreprendrait de longues et pénibles ascensions, non pour contempler de sublimes paysages, mais pour goûter la saine fatigue de la marche."

M. Radau was elected an Associate of the Society on 1905 June 9.

In Mrs. FLEMING the Society loses one of the only five* women who have ever been elected to Honorary membership. Although all her astronomical work was done in the United States, and must be credited without any reservation to the Harvard Observatory, she was by birth a Scotswoman, and did not go to America until after her marriage. Her engrossing work prevented any thought of a return to her native land, even for a holiday, until recently; and the sad news of her death came just when many friends were hoping to see her once more on this side of the Atlantic. There had indeed been some warnings that all was not well: within the last year or two more than one serious operation, which she bore with unflinching courage, had been necessary; but she had recovered so completely that her friends in Boston had no hesitation in urging her to undertake the long journey to California in September 1910 for the meeting of the Union for Solar Research on Mount Wilson. Undoubtedly she was fatigued at times, but went through the whole programme, and had the pleasure of visiting her son (now an engineer at Salt Lake City) on the return journey. On arriving home, she found a few days' rest advisable, but was soon back at work and promptly found two more "new" stars (making her total 10 out of the 17 discovered in the last 25 years). A few months later, however, she became seriously ill, and the end came on May 21 last.

Williamina Paton Fleming was born at Dundee 1857 May 15. We learn from a notice of her life and work prepared by Professor E. C. Pickering that she "belonged to the family of the Claverhouse Grahams, the 'fighting Grahams.' She inherited in a marked degree many of the best characteristics of this distinguished family—energy, perseverance, and loyalty. Her great-great-grandmother lived in the Dower House in Stirling, Scotland, which passed to another branch of the family for lack of male heirs; Captain Walker of the Seventy-ninth Highlanders eloped with and married her daughter. He served under Sir John Moore in the Peninsular

* The others are or were, Caroline Herschel, Mary Somerville, Anne Sheepshanks, Agnes Mary Clerke, and Margaret Lindsay Huggins. The name of Miss Sheepshanks is sometimes overlooked, and it is true that the grounds for her election differ somewhat from those in the other cases. She did no astronomical work herself, but her gifts (of £12,000 in all) have greatly benefited the Cambridge Observatory, providing the transit-circle and the Sheepshanks Telescope with which recent parallax and Eros work was done; besides attracting various mathematicians to Astronomy through the Sheepshanks Astronomical Exhibition. See *Mon. Not.*, xxxvii. p. 143.

War, and, like his leader, was killed at the battle of Corunna. His wife had accompanied him, and gave birth to a son, John Walker, Mrs. Fleming's grandfather, on the same day, and on the field of battle. Captain Walker's son-in-law, Robert Stevens, settled in Dundee, and was one of the first to experiment with photography in that city."

"Mrs. Fleming began work at the Harvard Observatory in 1881. Her duties were at first of the simplest character, copying and ordinary computing. Later, as her powers developed, she was advanced until she occupied one of the most important positions in the Observatory. . . . The work she left unfinished will fill several of the quarto publications of the Observatory. . . . Her principal published work will be found in volumes 13, 18, 26, 27 and 47 of [the Harvard] *Annals*, and in many of the Circulars of the Observatory."

The most casual inspection of these specified volumes fills us with admiration for the amount, the effectiveness, and the novelty of Mrs. Fleming's work. Take, for instance, volumes 26 and 27, which represent the work on the Draper Memorial, resulting in a Catalogue of the photographic spectra of 10,351 stars north of -25° . The work was commenced by Miss N. Farrar, but the "greater portion of it, the measurement and classification of all the spectra, and the preparation of the Catalogue for publication, has been in charge of Mrs. Fleming." Eight computers are named as having assisted her at different times, but to work through computers is rather a change of method than a relief from labour; and it was not the least part of Mrs. Fleming's work to have organised a great deal of computing work, and trained others to follow her in the operations requiring judgment. Or take, again, Part 1 of vol. xlvii.: "Mrs. Fleming has selected and measured the positions of a sequence of [comparison stars for studying photographically] each of 222 variables discovered [at Harvard] by her, or under her direction." Many astronomers are deservedly proud to have discovered one variable, and content to leave the arrangements for its observation to others: the discovery of 222, and the care for their future on this scale, is an achievement bordering on the marvellous.

And the same volume gives us an illustration of the effectiveness of this work. "The greater portion of these [variables] has been found from the characteristic spectrum, Md, which indicates the third type traversed by bright hydrogen lines. While many variable stars of long period have spectra of the fourth type, and a few have spectra of the third type in which the hydrogen lines are not bright in the photographs, no case has yet been found in which a star having the spectrum Md, described above, is not variable." Here is a generalisation of obvious significance, gathered in the course of arduous labour. It is only too easy to miss such points when dealing with thousands of observations—to miss "seeing the wood because of the trees"—but the Harvard workers were alert. Another generalisation of great importance was early

seized by them, relating to the distribution of Wolf-Rayet stars in the Milky Way and Magellanic Clouds. It would not be fitting, and it might not be possible, to attempt to separate out the exact share in such advances due to Mrs. Fleming herself; and certainly nothing could be farther from the intentions of the writer than to ignore the influence of the Director of an observatory, and especially of the Harvard Observatory; but Professor Pickering's own generous words about his assistant have paved the way for appreciation without fear of misconception.

The effectiveness and the novelty of Mrs. Fleming's work appear almost more clearly in the Circulars than in the volumes. These Circulars began to appear in October 1895 as a means of making prompt announcement of the results of work; and the first of them deals with Mrs. Fleming's discovery of a New Star in Carina. The second deals with Mr. Bailey's variables in clusters, but the variability had been "confirmed independently by Mrs. Fleming"; and so, in one way or another, as accessory if not as principal, Mrs. Fleming appears explicitly in 17 Circulars out of the first 25. No. 4 relates to another New Star—her fourth, she increased her total ultimately to ten; and in No. 20 we find that, as the result of her examination of many thousand plates, "numerous remarkable objects have been discovered. One of the latest is the spectrum of a meteor which has thus been photographed for the first time." The Circulars, however, do not all contain announcements of discoveries; some of them, for instance, foreshadow plans of work or administration; and the activities of the observatory expanded in new directions. For such reasons the name of Mrs. Fleming afterwards occurs less frequently. But when, for instance, in Circular No. 54 we have "64 new variable stars" announced, all but 11 of them have Mrs. Fleming's name attached; and several Circulars deal with "objects having peculiar spectra" almost all discovered by her. Her catalogues of stars having peculiar spectra are among the unpublished work mentioned above; fortunately they are nearly completed and are partly in type. There is also a catalogue of several thousand stars whose spectra are of the third type: there are "Journals of the variables she discovered, showing the photographic brightness of each on several hundred plates: sequences of stars in 48 standard regions: and classification of about 1500 stars in the same region, forming a catalogue now in type."

As an astronomer Mrs. Fleming was somewhat exceptional in being a woman; and in putting her work alongside that of others, it would be unjust not to remember that she left her heavy daily labours at the observatory to undertake on her return home those household cares of which a man usually expects to be relieved. She was fully equal to the double task, as those who have had the good fortune to be her guests can testify: and it is perhaps worthy of record, as indicating how lightly the double burden sat on her, that she yielded to none in her enjoyment of a football match, especially a match between Harvard and Yale.

She was the only Honorary Fellow of Wellesley College, an active and enthusiastic charter member of the Astronomical and Astrophysical Society of America, and a member of the Société Astronomique de France. Last winter she received the Guadalupe Almendaro gold medal of the Sociedad Astronomica de Mexico. She was elected an Honorary Member of this Society, 1906 May 11.

H. H. T.

PROCEEDINGS OF OBSERVATORIES.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.
(*Director, Dr. F. W. Dyson, Astronomer Royal.*)

Transit-Circle.—During the year 14,111 observations have been obtained. The Sun was observed 176 times and the Moon 122 times. Reflexion observations of stars were obtained on 86 nights.

The working catalogue of stars contains the fundamental stars observable in this latitude, and all stars down to magnitude 9.0 and a few fainter ones within the limits of Declination 24° to 32° N. (the Oxford Astrographic zone). Work on this catalogue was begun in 1906, so that 6 years out of the 10 originally allotted to it have now elapsed. A very closely proportionate number of observations have so far been obtained, the average number of observations per zone star being 3.0 out of the 5 required. Largely owing to the remarkably fine summer this year, the portion of the catalogue between 16^h and 24^h has been very fully observed; but the portion between 5^h and 10^h is much behind, owing to the cloudy weather last winter and this.

The sidereal standard clock has been removed from the magnetic basement to a new clock-room near the lower computing-room in the old part of the Observatory.

Altazimuth.—During the year 1924 observations of meridian transits have been obtained. The Moon has been observed 90 times on the meridian, and there were 31 extra-meridian observations made during the first and last quarters. The number of reflexion observations of stars is 273.

The Altazimuth Ten-Year Catalogue for the years 1899–1908 is completed, with the exception of the introduction.

The determination of the Moon's parallax made by the Royal Observatories of Greenwich and of the Cape of Good Hope from observations of the crater Mösting A 1906–10, has been published in *Monthly Notices*, vol. lxxi. pp. 526–540.

Reflex Zenith-tube.—A discussion of the observations made during the years 1906–9 showed that there was little hope of this instrument in its present form giving results of the accuracy now required in this work. Accordingly on August 24 the Reflex Zenith-tube was superseded by the Floating Zenith-telescope, and

observations with the former were discontinued; between January 1 and August 24, 881 double observations were obtained.

Cookson Floating Zenith-Telescope.—This instrument, which was designed by and belonged to the late Mr. Bryan Cookson, was presented to the Cambridge Observatory by Mrs. Cookson. It has been lent by Cambridge Observatory to Greenwich for a period of seven years. The hut and instrument were brought here and erected in the courtyard, by the side of the Longitude Pavilion, at the beginning of August.

Whilst the observations with such an instrument lead to a determination both of Latitude Variation and of the Constant of Aberration, the working programme has been especially drawn up with a view to obtaining a good determination of the latter constant. Some changes have been made in the mode of observation. In place of observations of a single star in direct and reversed positions near the zenith, the Talcott method of star-pairs has been adopted. It has also been found possible to avoid the use of a *réseau*.

The final adjustments were made on October 2, and from that date to the end of the year 32 plates, each containing 4 or 5 Talcott pairs of stars, have been taken. In addition plates were taken for the adjustments and determination of the scale-value of the telescope; the total number of plates exposed is 66.

Occultations.—During the year 16 disappearances of stars occulted by the Moon have been observed by one or more observers.

28-inch Refractor.—689 double stars have been measured, each star generally on two nights. These consist of—

121	pairs under	0.5	separation.
138	„ between	0.5 and 1.0	separation.
161	„ „	1.0 „ 2.0	„
269	„ over	2.0	separation.

70 Ophiuchi was observed on 13 nights, δ Equulei and κ Pegasi each on 5 nights.

In addition the diameter of Venus was measured on 8 nights, of Mars on 9 nights, and of Saturn and the ring-system on 3 nights.

Thompson Equatorial.—This instrument has been employed chiefly in the determination of stellar parallaxes with the 26-inch Refractor, and in photographic photometry with the 30-inch Reflector and a 6-inch lens lent by Mr. Franklin Adams.

In determining stellar parallaxes Professor Kapteyn's method with a slight modification has been adopted. Instead of exposing the same plate at the beginning, middle, and end of a parallactic cycle, it was thought safer to break the whole cycle into two halves; thus, when the second exposure is obtained after six months, the plate is developed, the cycle being continued on a fresh plate.

73 plates have been exposed on Kapteyn areas (chiefly the

Pole), with an exposure of 20 minutes, and for 21 of them the half-cycle has been completed.

136 plates have been exposed on 38 stars of large Proper Motion, 4 stars of the Wolf-Rayet type, and 3 planetary nebulae. 19 of these plates have been re-exposed at the $\frac{1}{2}$ cycle.

With the 30-inch Reflector.—66 plates were exposed on the Pole and on selected areas for the determination of photographic magnitudes in connection with the counting of stars on the Franklin-Adams chart plates.

20 plates were exposed in a search for certain of Herschel's nebulae whose identity was doubtful.

6 plates were exposed on Comet *b* 1911, 28 on Comet *c* 1911 (18 of which received long exposures for the features of the tail), and 4 on Comet *f* 1911.

With a 6-inch Lens, lent by Mr. Franklin Adams, 49 plates were exposed for photometric comparison in pursuance of a programme for determining the photographic magnitudes of stars brighter than 8^m.8 to supplement the similar work for fainter stars with the Astrographic telescope.

In addition a number of miscellaneous photographs were taken with one or other of the telescopes. Altogether 245 photographs were taken with the Refractor, 145 with the Reflector, 65 with the 6-inch lens, and 31 with other attached lenses.

The following results have been published in the *Monthly Notices*:—Observations of Comets 1909-1910; Observations of Nebulae; Observations of Saturn's Ninth Satellite (Phœbe) 1910.

Astrographic Equatorial.—During the year 443 plates have been taken, 22 being photographs of comets, 18 of Nova Lacertæ, while 13 were taken for adjustment of the telescope and for miscellaneous purposes. The remaining 390, of which 300 were kept for measurement, were taken for the investigation of the photographic magnitude of stars of the *Astrographic Catalogue*, Greenwich section, mentioned in last year's report. These plates have been exposed to fields of the Astrographic Catalogue when at the altitude of the Pole, and also to the field which has the Pole itself as centre before and after the exposure to the Astrographic field, the duration of exposure being in all cases 10 minutes. By comparing the measured diameters of certain selected stars of the Astrographic field with those of the stars of Professor E. C. Pickering's North Polar Sequence, comprised in the Pole field, the magnitudes of the selected stars are determined. These are then used as reference stars, by help of which the magnitudes of all the stars in the Astrographic Catalogue may be deduced from their measured diameters given in the volumes already published. This method provides for the determination of the magnitudes of stars of 8^m.8 and fainter; but for the bright stars it has been found necessary to take special photographs with a lens covering a larger field, in order to obtain suitable polar comparison stars (see *Thompson Equatorial*).

To obtain sufficient data for the determination of the magnitudes

over the whole zone, 420 fields are being photographed, those of the even degrees of declination being, in general, taken. With the 23 plates reported last year, there are now 323 fields available; 200 of these have been measured in 1911 and the magnitude constants of 150 plates of the *Astrographic Catalogue* have been deduced.

During the year a catalogue in standard rectangular coordinates of 2200 stars (of which 1400 are brighter than magnitude 13.0 on the scale of Professor Pickering's Polar Sequence, and 800 are fainter), within 3° of the North Pole, has been formed from the measures given in vol. ii. of the *Astrographic Catalogue*, pp. 926-996. This catalogue, which contains also the photographic magnitude, is now in the hands of the printers.

The preparation of the Catalogue of Right Ascensions and Declinations of Stars mentioned in previous reports has been continued. The positions of the stars in the zones of declination 64° , 65° , and 66° , about 2400 in all, have been computed, the work involving the conversion of measures of about 5400 images. This completes the actual computation. Some time has been spent in examination of the work, and in revision of plate-constants when found necessary.

To complete the catalogue, the photographic magnitudes are being determined by the method above explained.

Counts of Stars on the Franklin-Adams Chart Plates.—During the past year progress has been made with the enumeration of stars, according to their photographic magnitudes, on the chart plates lent by Mr. Franklin Adams. The months January and February were occupied in making various preliminary arrangements, and the actual counting began on 1911 March 13. 86 plates were counted up to 1911 December 31, 34 of the earliest counts having been repeated. The total number of plates to be counted is 206, covering the whole northern and southern sky. The faint stars in 25 regions, uniformly distributed over each plate and of areas varying from about 80 to 800 square minutes, are classified according to their magnitudes, ranging from the tenth to the seventeenth magnitude. The photographic magnitudes of a number of selected stars at the centre of each plate are to be determined by comparison with the stars of Professor E. C. Pickering's North Polar Sequence, on photographs taken with the 30-inch Reflector (as mentioned above). 66 of these auxiliary plates have been taken; 26 were rejected owing to incomplete exposure, faulty sky, or other causes, while of the 40 plates which were provisionally passed, 16 have already been completely examined.

Photoheliograph.—Photographs of the Sun have been taken on 227 days during the year 1911. Of these photographs, 502 have been selected for preservation, including 23 with double images of the Sun for determination of the zero of position of the wires.

The photographs taken at Greenwich have been supplemented by photographs taken at the Royal Observatory, Cape of Good Hope, under the direction of H.M. Astronomer; the last supply of

these received by the end of the year extends to the end of October. In the year ending 1911 October 31 photographs were taken at the Cape Observatory on 294 days, of which 594, including 20 with double images of the Sun for determination of the zero of position of the wires, have been received at Greenwich. The Greenwich and Cape series supply together photographs for 344 days out of the 365. Of this number 216 Greenwich and 128 Cape photographs have been selected for measurement. To complete the series 13 photographs from Dehra Dûn and 4 from the Kodaikânal Observatory have already been measured, and 3 more are expected to come to hand, leaving only one day, 1911 January 1, unrepresented.

The photographs taken at Greenwich have been measured up to 1911 November 21, the Cape photographs to the end of 1911 September, and those from the Indian Observatories as far as they have been received.

The complete photoheliographic results for 1910 have been passed for press; and the measurements and reductions of the photographs for 1911 are completed, and the copy for press is prepared for the printer up to the end of September.

The solar activity has shown a great decline in 1911 as compared with the preceding year, and the period of the sun-spot minimum is evidently close at hand. Advantage has been taken of the decrease of the work of measurement and reduction to commence an inquiry into two subjects—to ascertain whether there is any evidence of a systematic drift in latitude of the groups of spots, and to determine the error of the assumed position of the Sun's pole.

Printing.—The copies of the volume of Greenwich Observations for 1909 were distributed in July 1911; this includes as an Appendix the "Investigation of the Motion of Halley's Comet from 1759 to 1910," by P. H. Cowell and A. C. D. Crommelin.

The printing of the Greenwich Observations for 1910 is nearly complete, the last sheets of the astronomical part of the volume are now passing through the press.

Royal Observatory, Cape of Good Hope.
(*Director, Mr. S. S. Hough, H.M. Astronomer.*)

Transit-Circles.—With the exception of a few observations for time determinations with the non-reversible transit-circle while the new instrument was undergoing alterations, work for the year has been restricted to the latter instrument. The programme consisted in the observation of a series of stars within 10° of the South Pole, together with the necessary time stars. The following observations have been obtained during the year :—

Observations of Right Ascensions:—

	Reversible T.C.	8-in. T.C.
Number of meridian transits.	5221	80
Determinations of collimation by collimators	100	37
„ by reflexion and reversal	16	
Determinations of level . . .	747	23
„ azimuth . . .		8
Observations of N. azimuth mark	1280	
„ S. „	1280	

Observations of Zenith Distances:—

Determinations of Z.D. . .	4428
„ runs . .	322
„ nadir . .	724
„ flexure . .	49

The number of observations with the reversible transit-circle include observations of the Sun on 117 days, Mercury on 43 days, and Venus on 70 days.

The transit observations of circumpolar stars have been made throughout by the method of causing a travelling wire, driven by a clock movement at approximately equatorial speed, to transit across the almost stationary star, alternately from east to west and from west to east. The times of transit are recorded by means of chronograph and key in the manner usually adopted for time observations, the instantaneous position of the travelling wire being simultaneously recorded on the chronograph by means of the self-registering drum-head of the micrometer.

To facilitate comparison between different observers, nearly two hundred transits have been observed by two different observers, one observing over the preceding half of the field and the other over the following half.

A reduction of these observations indicates discrepancies between the individual observer and the mean of all observers amounting at a maximum to 0".18, and in no case materially exceeding the probable error of determination.

The azimuth variations of the instrument have been derived from the meridian marks provisionally assumed stationary throughout the year.

The observations have then been combined in approximately fortnightly groups, corresponding with the period between successive reversals, and the fluctuations of the marks themselves determined as residual phenomena so as to render the group results concordant, the absolute azimuth of the marks depending similarly on the concordance of the observations above and below Pole during the winter months. The results, derived by a combination of observations made in the two clamps, indicate that the variations of azimuth of the meridian marks throughout the year closely follow

the Eulerian motion of the Pole as derived by extrapolation from the investigations of Albrecht from the observations at the International Latitude Stations.

There is, however, a discrepancy which varies through the year between the observations made in clamp E and those made in clamp W which seems irreconcilable with the direct determinations of collimation made either in the horizontal or the vertical position of the instrument, or with the errors of the pivots as directly determined.

The observations of the lunar crater Mösting A have been discontinued during the year. The results of the declination observations made in previous years have been communicated to the Astronomer Royal, and have been utilised in conjunction with the corresponding observations made at Greenwich for an investigation of the lunar parallax which has been communicated to the Society.

The reductions of transit observations to apparent place have been completed to the end of the year, and of the meridian zenith distances to September 11. During the year mean places have been derived for the observations of 1905, 1906, 1907, and for the right ascension observations of 1911, and the formation of a catalogue from the observations of 1905-11 has been commenced.

Helimeter.—This instrument has been used as in previous years for the observation of the major planets in opposition. The following observations have been obtained :—

Opposition of Neptune	.	42	obs. of distance on 7 nights.
„ Uranus.	.	34	„ „ 5 „
„ Saturn.	.	44	„ „ 7 „
„ Jupiter.	.	41	„ distance
		25	„ position angle
„ Mars .	.	44	„ distance
		4	„ position angle
} on 9 nights.			
} „ 7 „			

The observations of major planets made in the course of the years 1905-10 have been reduced during the year, and the corrections to the Nautical Almanac Ephemerides derived.

Victoria Telescope and Astrographic Laboratory.—The instrument has been used throughout the year in conjunction with the four-prism spectrograph train in the photography of stellar spectra. Observations were obtained on 182 nights, and in all 424 plates of stellar spectra were secured, in addition to 61 daylight plates and 23 focus plates. During the year 400 plates have been measured in the Hartmann comparator and 4 in the wave-length micrometer. A second Hartmann comparator, which will enable the measuring in future to proceed at a more rapid rate, has been kindly presented to the establishment by Sir David Gill.

A discussion of the measures of plates taken previously to July 1908 has been issued during the year as part i. of vol. x. of the *Cape Annals*.

A short paper "On the Spectrum and Radial Velocity of ϵ Canis Majoris" has been sent to press as an appendix to part ii. of vol. x. of the *Annals*.

Astrographic Telescope.—The following photographs have been secured during the year with the astrographic telescope:—

Description of Plate.	No. of Plates.	No. of Exposures.	Duration of Exposure.
Magnitude plates	40	160	20 ^m , 6 ^m , 20 ^m , 6 ^m
Catalogue plates	2	6	6 ^m , 3 ^m , 20 ^s
Plates taken for Greenwich	6	12	20 ^m , 20 ^m
Hector	8	12	various
Minor planet region	2	5	various
Comet Kiess	17	17	various
Comet Encke	9	9	various
Comet Borrelly	12	12	various
Comet Brooks	11	18	various
Comet Quénisset	2	3	various
Adjustments	1	2	20 ^m , 31 ^m

Each of the "magnitude" plates has been exposed on two regions in accordance with the programme suggested at the last meeting of the Astrographic Congress in Paris, with a view to the coordination of the stellar magnitudes in the Cape astrographic zone. The catalogue plates are in revision of plates previously taken for the purposes of the *Carte du Ciel* catalogue, but which have been found defective in the course of the reductions. The regions photographed for Greenwich were taken at the request of the Astronomer Royal as supplementary to the observations secured at Helwân of Jupiter's eighth satellite. The plates of the planet Hector and of other regions in search of minor planets were taken at the request of Professor Strömgren and Mr. Innes.

Astrographic Reductions.—As stated in last year's report, it was decided to defer publication of the *Carte du Ciel* catalogue results until plate-constant corrections had been applied and the results had been subjected to the control which could be furnished by a comparison of overlapping areas on adjacent plates. During the year these plate-constant corrections have been computed in whole or in part for each star on some 493 plates and applied to the measures of 441 plates. The copy for press has been completed for 390 plates. The control computations have been effected for 276 plates and the discordances examined for 498 overlapping quadrants.

At the present time the whole of the plate-constant corrections for each star of the 1512 plates involved in the Cape Zone have been computed, while for 1054 of the plates they have been applied and examined.

The copy for press, subject to final control, has been prepared for 901 plates and finally passed for 342.

The extreme northerly zone has been verified by comparison with the overlapping area of the Perth (Western Australia) Zone

from MS. copy of the results obtained in Edinburgh, which has been kindly furnished by the Astronomer Royal for Scotland.

The first six hours of zone -41° have been forwarded to the printer, and a specimen page approved, but no proof-sheets have yet been received.

Photoheliograph.—Daily photographs of the Sun to supplement the Greenwich series have been secured on 293 days. In all 603 negatives have been taken, of which 8 have been rejected and the remainder forwarded to Greenwich.

Occultations.—Seventeen separate phenomena of occultations of stars by the Moon have been observed during the year, viz.—

Disappearances at dark limb	. . .	11
Reappearances ,, ,,	. . .	6

Miscellaneous.—Investigations relating to the systematic distribution in the positions and motions of the stars have been continued, and a further contribution on this subject has been communicated to the Society (*M.N.*, vol. lxxi. pp. 610–639).

Some further investigations on the methods of adjusting photographic plates on the lines developed in the report to the Astrophysical Congress (*Rapport du Comité International Permanent*, 1909, page B, 75) have been carried out during the year.

The time-signal service, meteorological observations, and seismograph records have been maintained as in previous years.

By invitation of M. Baillaud, H.M. Astronomer attended the International Conference of Directors of Nautical Ephemerides and Astronomers held in Paris in October.

Royal Observatory, Edinburgh.

(*Director, Professor R. A. Sampson, Astronomer Royal for Scotland.*)

Transit-Circle.—Observations with the transit-circle have been confined to those necessary for time service. The method of illuminating the field has been altered. This was, by light received through the axis, reflected by a plate within the cube to a small mirror sealed to the front of the object-glass, and thence back to the field. During some very damp weather the small mirror went out of order and was removed. The illumination is now made by means of a small electric lamp within an ebonite box with a dulled window suspended symmetrically by wires about two inches in front of the object-glass.

Solar Spectroscopy.—The observations of the Sun's rotation made from 1908 to 1910 were discussed and published in *Monthly Notices*, June 1911. These were made photographically with a comparison of solar and telluric lines in different latitudes. This method confines the investigations to portions of the spectrum where telluric lines occur. An arrangement of prisms has now

been made which will bring at will the images of two points of the Sun's disc simultaneously upon the slit, one occupying the middle of the slit and the other the two edges. Several photographs were taken in the blue and with long exposures in the infra-red to determine the best method of mounting and adjusting the prisms. These, as far as they went, were very satisfactory. The instrument has also been overhauled in other details. The prism for separating the overlapping spectra of different orders has been removed and its work done by means of light filters just behind the slit.

Astrographic Plates.—Measurement and reduction of the astrographic plates taken at Perth, Western Australia, have been continued. The plates of zone -39° from R.A. $7^h 45^m$ to $23^h 55^m$ have been measured with the exception of six plates on which the *réseau* was defective. These will be retaken. For the greater part of zone -39° copy of the measures is ready for press. For zone -40° copy has been sent to the Cape for comparison with their overlapping portion and has been returned. This completes zone -40° , which is also ready for press.

Mr. Wrigley collected the pairs of double stars shown in zone -40° and published the resulting photographic measures with a brief discussion in *Monthly Notices*, November 1911.

Fifteen-inch Equatorial.—Double-star observations have been continued upon the same programme as hitherto.

During the months of August, September, and October photographic observations of Comet Brooks (1911 c) and of its spectrum were made whenever possible with cameras attached to the fifteen-inch. A good series was obtained. The spectrum was measured and the results communicated to the Society and published in *Monthly Notices* for November 1911.

Twenty-four-inch Reflector.—This large instrument has never given results commensurate with its proper power, though in the past Mr. Heath obtained some fair photographs of nebulae with it. As its images were always much inferior to those of the six-inch photo-visual mounted on the same base, the mirror was removed from its cell for examination. The examination was not reassuring, and the mirror was sent to Mr. Calver for a more exact report. Meanwhile some old correspondence came to light, and the report received from Mr. Calver was exactly confirmed by one which had been made by Mr. Cooper Key so long ago as 1875. There is no doubt that the figure of the mirror is seriously defective.

Seismograph.—Photographic observations have been made regularly with the Milne seismograph. The records have been read and the results for 1911 communicated to Mr. Milne.

Meteorology.—Meteorological observations have been carried on regularly. These include a photographic record of air-potential by means of a water-dropping electrograph of Kelvin's type.

Armagh Observatory. (Director, Dr. J. L. E. Dreyer.)

Most of the work done has been in connection with the edition of the collected papers of William Herschel, now in the press. The revision of the three catalogues of nebulae, mentioned in last year's report, has been completed, and a number of unpublished observations extracted from the records.

The 10-inch refractor has occasionally been used for the verification of doubtful cases, both as regards nebulae and double stars.

The collation of the original manuscript observations of Tycho Brahe has been completed. Some gaps in the volumes preserved at Copenhagen were filled by photographing or copying the missing parts from the contemporary copy of the observations belonging to the Hofbibliothek at Vienna. This part of the work was done by Dr. Krumpholz of the Vienna Observatory.

Cambridge Observatory. (Director, Sir R. S. Ball.)

1. *Meridian Circle.*—In the observation of Gill's Zodiacal Catalogue, 590 stars have been observed on 27 nights. The reductions to apparent place in Right Ascension are complete to 1907 December 5, and in North Polar distance to 1910 March 3. The reductions to mean place are complete to 1907 December 5. Clock stars have been observed daily as far as weather permitted.

The volume now in the press containing the ledger of observations for the Cambridge Zone Catalogue is printed as far as R.A. 19^h 38^m.

Mr. Hartley has had charge of the observations and reductions in this department.

2. *Sheepshanks Telescope.*—A few plates to complete stellar parallax series have been obtained. The exceptionally cloudy winter weather has again almost prevented observation at the epochs at which plates were required. Considerable progress has been made with the measurement and reduction of about fifteen series.

Other observations with the Sheepshanks telescope include observations of Nova Lacertæ (*M.N.*, 1911 Jan.); observations of the variable 97.1910 discovered here last year; a second series of photometric plates on selected Kapteyn areas, in continuation of those described last year; and visual examination of a list of nebulae of which observations were required in connection with a discussion of the galactic distribution of nebulae, now in progress.

Professor Barnard has very kindly followed the variable 97.1910 when it has been beyond the reach of the Cambridge instruments. He finds that it falls below the magnitude 16.5, and becomes invisible in the forty-inch of the Yerkes Observatory. But the observations are not yet sufficient to determine the period.

The Carnegie Institution of Washington has published, as No.

147 of its publications, Professor Russell's Determinations of Stellar Parallax, based on plates taken with the Sheepshanks telescope in the years 1904-1907, as described in previous reports.

Mr. Hinks has had charge of the Sheepshanks instrument throughout the year.

3. *A research on the Aberration Constant and the Variation of Latitude by means of a floating zenith-telescope*, by the late Bryan Cookson, has been published during the year in the *Memoirs, R.A.S.*, vol. lx., part ii.

The catalogue of the photographic positions of 6000 stars, prepared by Mr. Hinks in the course of his work on the Solar Parallax, is now in the press, and will appear in Tome VI. of the *Bulletin du Comité Permanent*.

4. The usual courses of instruction in practical astronomy, and in field astronomy for surveyors and geographers, have been given by Mr. Hinks during the year.

*The Newall Telescope, and Astrophysical Department,
Cambridge Observatory. (Professor H. F. Newall.)*

The Newall telescope has been used mainly for visual observations of the spectra of nebulae. This work has been undertaken to give a rapid survey of objects from which the more interesting should be selected for subsequent examination by photographic methods. Between April 19 and the end of the year this nebular work was carried out on 28 nights, and 151 objects have been examined. Of these, 88 have been placed on the list of those fully observed, and may be classified as follows:—

- 25 giving a continuous spectrum (probably spiral nebulae).
- 17 loose clusters.
- 7 globular clusters.
- 12 planetary nebulae.
- 8 planetary nebulae—stellar.
- 2 annular nebulae.
- 2 gaseous nebulae—irregular.
- 6 doubtful.
- 9 too faint.

The telescope was also used for visual examination of the spectra of Nova Lacertæ and of several of the brighter comets. Two short notes were communicated to the *Astronomische Nachrichten* (189, 85 and 359). This work has been in the charge of Mr. Stratton.

Mr. Stratton has also investigated a method of utilising numerous standard lines in the reduction of spectrograms (*M.N.*, lxxi. 663), and has completed a discussion of possible relations between sun-spots and the planets (*M.N.*, lxxii. 9).

A careful examination is now in progress of the spectrograms of Nova Persei, secured in 1901 but not yet thoroughly discussed.

The work on the solar rotation by spectrographic methods has been continued by Mr. Hubrecht.

The Huggins refractor has been in the charge of Mr. Brunt. The spectroscope has been thoroughly examined and tested; and in order to obtain a higher dispersive power for determining radial velocities, a new spectrograph is being constructed. Meanwhile one of the quartz spectrographs has been fitted for use as a slitless spectrograph with the reflecting telescope for the examination of the spectra of Novæ and Nebulæ. Mr. Brunt is also engaged in an examination of the theory of anomalous dispersion as applied to solar phenomena.

Mr. Capstick is continuing his photometric researches on spectral lines.

Lectures were given by Professor Newall and Mr. Stratton on Stellar Physics, in the Lent term; and by Mr. Stratton on the Combination of Observations, in the Michaelmas term.

Dunsink Observatory.

(*Director, Professor E. T. Whittaker, Royal Astronomer of Ireland.*)

The staff consists, as at the close of the previous year, of the Director and Mr. C. Martin, Assistant; the instruments in regular use are the Pistor and Martins meridian circle and the Roberts photographic reflector.

The time-service to Dublin has been continued as in previous years.

Three hundred and ninety-eight plates have been taken during the year with the Roberts reflector in connection with the observing list of variable stars. All plates taken before 1911 September 30 have been measured.

The new 6-inch doublet has been delivered by the maker, and mounted.

The professorial courses of post-graduate lectures by the Director and the demonstrations in practical astronomy by the Assistant Astronomer have been given as in previous years, and the South Equatorial has been employed on the first Saturday in each month in showing objects of interest to visitors.

University Observatory, Durham.

(*Observer, Mr. F. C. H. Carpenter.*)

The work of the Observatory during the early part of the year was the completion of the calculation of the times of phenomena of Jupiter's Satellites III. and IV. for the Nautical Almanac 1914: the tables used being those by Sampson, and published by this University.

Other calculations with the Tables have also been made.

In the summer some experimental work was started with the

Transit Instrument, but had to be abandoned owing to the telescope being found faulty.

The Almucantar has been used for time observations. It was dismounted some time ago, and is now in the hands of the makers, undergoing alterations. It is hoped that the telescope will soon be returned, when systematic work will be continued with it.

Regular meteorological observations have been taken throughout the year.

Glasgow Observatory. (Director, Professor L. Becker.)

The 20-inch reflector was principally used in photographing the spectra of planets. In September and October every available night was taken up with Brooks' Comet 1911 c, and a film was exposed in the large dispersion spectrograph on seven nights, for a total of 15.3 hours, with practically no result. Five photographs of the same comet were, however, obtained with a prismatic camera of $3\frac{1}{4}$ -inch aperture, attached to the tube of the reflector.

The time service and meteorological observations have been carried on as in former years.

Liverpool Observatory. (Director, Mr. W. E. Plummer.)

During the past year there has been no alteration in the work of this Observatory, and the instrumental equipment remains the same. The slow but gradual increase in the number of instruments submitted to test, satisfactory from one point of view, continually demands from the small staff greater attention to routine work. The meteorological observations are heavy, and cannot well be reduced. Under these circumstances it has been found possible only to keep the Transit Instrument at work for the determination of time, with the view of accurate distribution of time signals. The equatorial has been employed for the observation of comets as in previous years, but, for the reasons mentioned above, the reduction of the observations has fallen into arrears. Other objects, such as double stars, are occasionally observed.

With regard to the seismometer observations mentioned in the last report, very considerable difficulty has been experienced in determining the scale value with accuracy, since it varies with the angle between the direction of the main boom and the magnifying lever. Such observations as have been made with the pendulum in different azimuths tend to show that in any position the displacement is the same. The conclusion is that the deflections are independent of the river or topographical arrangement, and are occasioned by causes operating from a distance. The instrument used for the registration of unfelt tremors is undergoing reconstruction with a view to the increase of the time scale and to introduce further improvements suggested by modern observations.

Radcliffe Observatory, Oxford.
(*Director, Dr. Rambaut, Radcliffe Observer.*)

The work at the Radcliffe Observatory during 1911 has been conducted on much the same lines as in recent years. The 24-inch photographic refractor has been chiefly employed in obtaining plates of selected regions for determining the proper motion of stars down to the 14th magnitude.

For this purpose the plates are given two exposures of thirty minutes, and each region is photographed in duplicate on separate plates, of which one is developed in the ordinary way, and the other stored away undeveloped to be exposed again to the same region when a sufficient number of years has elapsed. In connection with this scheme 73 plates have been obtained. Of these 6 were judged to be imperfect or incomplete, leaving 67 which are considered satisfactory. During the year 36 such plates have been packed up undeveloped and stored in air-tight boxes.

Other objects photographed with this instrument are:—Espin's Nova Lacertæ on January 2 and 9, the star B.D. + 51° 3375 (suspected of variability), B.D. + 57° 1692 for proper motion, Brooks' comet, 1911c (10 plates), Quénisset's comet, 1911f (3 plates), the Moon (4 plates), and the region surrounding the Pole (4 plates) to determine the limits of magnitude on the proper motion plates.

The 10-inch Barclay equatorial has been employed for miscellaneous observations, including observations of Nova Lacertæ and comet 1911c. This instrument also continues to be employed by Mr. Barrett in his spare time for observing RW and ST Draconis, Nova Lacertæ, and other variable stars.

Considerable progress has been made during the year in the measurement and reduction of the parallax plates taken in recent years with the 24-inch refractor. In this connection five plates of the region surrounding B.D. + 44° 1408, taken on Prof. Kapteyn's plan, have been measured and reduced. Twelve plates of the region surrounding B.D. + 31° 1684 have also been completely measured and reduced. Of these two were taken on Prof. Kapteyn's plan pure and simple. That is to say, all the twelve required exposures in each case were made on a single plate. The other ten plates form five pairs, to which, for convenience, we have given the name of "split triples." In the case of split triples one plate of the pair contains three exposures made at the first selected epoch of maximum parallax factor, and three made similarly at the second selected epoch. The plate is then developed. The other component of the pair contains three exposures made at the second epoch and three made at the third epoch of maximum parallax factor.

The total number of measures made on these plates amounted to 47,512. These have all been fully reduced and the resulting parallaxes carried into a card-catalogue as a preliminary step

towards preparing the results for the press. This card-catalogue contains 810 separate determinations of the parallaxes of 340 stars in the region of B.D. + 44° 1408 (including 196 separate results for 115 stars deduced by Prof. Kapteyn at Groningen from two of our plates, which were sent to him some time ago for measurement), and 485 separate results for 145 stars in the region surrounding B.D. + 31° 1684.

The results appear to be of a high order of accuracy.

During the year 1911, vol. xlix. of the *Radcliffe Observations*, containing the results of the meteorological observations made at this Observatory in the years 1900-1905, was printed and published. The copy for press of vol. l., which will be a volume of a similar character containing the meteorological observations made during the years 1906-1910, was also prepared during the year and placed in the printer's hands before its close.

University Observatory, Oxford.
(Director, Professor H. H. Turner.)

The printing of the measures for the *Astrographic Catalogue* was completed with vol. vii. (zone + 25°) early in the year. The final volume (vol. viii.) of discussions is being prepared for press.

The comparison of photographs of the same region, separated by an interval of at least 10 years (the first having been found in some way defective), has now been completed by Mr. Bellamy, and the results communicated to the Society (*Monthly Notices*, lxxi. p. 582, lxxii. p. 65). In all 391 proper motions of over $15''$ per century were found on 183 plates; and these stars show no condensation towards the plane of the Galaxy.

In the March number of the *Monthly Notices* methods were sketched for determining the places of (1) Reference Stars and (2) Fundamental Stars by photographic methods. The attack on the second problem is deferred for the moment (though a "cube" of mirrors, the cost of which was defrayed by a friend, has been constructed by Professor G. W. Ritchey) in order to attack the first. Several plates have been exposed and measured, and a preliminary account of the results was presented to the Society at the December meeting. This work will probably absorb the main energies of the Observatory for a year or two.

Early in 1911 Mr. Bellamy made an accurate survey of the region of Nova Lacertæ, measuring the places of 300 stars (*Monthly Notices*, lxxi. p. 195), and Mr. Plummer studied the distribution of stars in globular clusters with marked success, obtaining very good accordance with a law for which there is a physical foundation.

Recently Mr. Plummer has been discussing a valuable mass of material, kindly put into his hands in MS. by Professor W. W. Campbell, consisting of stellar motions in the line of sight. A provisional discussion by Professor Campbell suggested that the type

A stars were moving nearly parallel to the Galaxy. By impressing this condition on the proper motions, Mr. Plummer ingeniously deduces the parallax of each star and its component motions in km. per sec.; and he finds several well-defined groups of stars with relative motions small compared with their common motion, the most interesting being a group of stars moving in the same direction as Professor Boss's Cluster in Taurus. These results were briefly communicated to the Society in January 1912.

Temple Observatory, Rugby. (Director, Mr. G. M. Seabroke.)

The educational work has been continued as in former years, a few boys taking sufficient interest to learn to measure double stars, etc. Mr. Hewlett, who lives at the observatory, has begun the measurement of double stars in continuation of what has been done in the past.

*Royal College of Science, South Kensington.
(Assistant Professor A. Fowler.)*

The instruments were chiefly employed for the instruction of students, but spectroscopic observations of sun-spots and prominences were occasionally made as in former years. Some excellent photographs of stellar spectra have also been obtained with the objective prisms on the 5-inch equatorial. The chief addition to the equipment has been a star photograph micrometer.

The laboratory investigations included the spectrum of the nitrogen afterglow (*Proc. R.S.*, 85 A, 377), the spectra of various elements and compounds excited by active nitrogen (in collaboration with Professor Strutt, *Proc. R.S.*, 86 A, 105), and the less refrangible part of the spectrum of cyanogen (*Proc. R.S.*, 86 A, 118). It is hoped that the last named will provide useful data for comparison with the spectra of comets and fourth-type stars. Other researches relating to the spectra of comets are in progress.

The Astrophysics department of the College has suffered a serious loss by the death of Mr. H. Shaw, who had for several years ably discharged the duties of demonstrator.

*Solar Physics Observatory, South Kensington.
(Director, Sir Norman Lockyer, K.C.B.)*

Observations of Sun-spot Spectra.—The Sun was visible on 228 working days during 1911, and observations of Sun-spot spectra were made on 26 days, 29 spots being examined in the F-b region. The chief widened lines are still those due to vanadium, titanium, magnesium associated with hydrogen, and scandium.

Spectroheliograph.—Attempts to secure photographs of the Sun in " K_{2-3} " light with this instrument were made on 157 days. 249 negatives showing the distribution of calcium flocculi were taken, and 220 of them have been selected for measurement and reduction. In addition to these, 61 "limb" negatives were obtained, thus securing a record of the prominences; on most of these an exposure was made on the disc as well.

In accordance with the arrangement made with the Indian Government, 332 spectroheliograms, showing the disc in "K" light, have been received from the Kodaikānal Observatory during 1911; these cover the period October 1, 1910 to September 30, 1911. Fifty glass positives of the Sun's limb in "K" light were forwarded from South Kensington to Kodaikānal during the year.

Areas of Flocculi.—The measurement and reduction of the composite series of daily spectroheliograms from Kodaikānal and South Kensington have been completed for the year 1907; and, in addition, measures have been made of the plates for subsequent years in duplicate to November 1908, and by one observer to November 1909.

Sun Photographs.—Daily photographs (glass negatives) of the Sun's disc, taken with the photoheliograph, have been received from Dehra Dûn and Greenwich.

Positives on paper are also received from Dehra Dûn, and these are mounted on cartridge paper and bound up in half-yearly volumes. Where necessary to fill gaps, prints are made from the Greenwich plates. Since the beginning of 1906 enlargements of spectroheliograms, when possible, have been mounted alongside the paper prints.

Laboratory Work.—In the laboratory attention has been devoted chiefly to a series of experiments, designed to elucidate problems of the chemical constitution of the vapours involved in sun-spots and lower-type stars. The flame, arc, or electric furnace spectra of various metallic elements have been photographed. As the electrical installation at the Observatory was not suited to the needs of furnace work, Dr. Glazebrook, Director of the National Physical Laboratory, was approached, and at once he courteously consented to place at the disposal of the Observatory the facilities existing at that Institution. An extemporised spectrograph was taken, therefore, to Teddington by one of the assistants, and the necessary spectrograms secured. Some of the results have been communicated to the Royal Society.

In connection with the interpretation of cometary spectra, various gaseous carbon compounds have been spectroscopically examined at low pressures under varied electrical conditions of excitation.

Night Work.—Observers attended on 151 nights, and photographs were obtained on 66 occasions. One photograph of the spectrum of Comet Brooks (1911c) was secured with the Hammersley spectroscope attached to the 36-inch reflector.

With various prismatic-cameras carried by the 10-inch equatorial mounting 82 photographs of 13 stellar spectra were taken.

With the 2-inch calcite-quartz spectrograph 13 pairs of stars were examined during 1911, and there were secured also 12 spectrograms of Comet Brooks (1911c).

Solar Eclipse 1911.—Arrangements were made to secure records of the total solar eclipse of 28th April 1911, at Vavau, in the Tonga group of Islands, South Pacific. Mr. F. K. McClean and other experienced volunteers, assisted by officers and men of H.M.S. "Encounter," under the direction of the Chief Assistant, carried out a long and arduous programme of work. Unfortunately, the eclipse was observed for the most part through clouds, and, consequently, the results were meagre.

Publications.—During the year a paper on "The Iron Flame Spectrum and those of Sun-spots and Lower-type Stars" has been published by the Royal Society. A report on the work of the Eclipse Expedition is now in the press. A paper on "The Spectrum of Comet Brooks (1911c)" has been communicated to the Royal Society. Papers in connection with the Widened Lines of various Elements recorded in Sun-spot Observations 1879-1908 and the Spectra of α Orionis, are nearly ready for publication.

Stonyhurst College Observatory.
(Director, Rev. W. Sidgreaves, S.J.)

The solar surface has been observed, and drawings of the spots and faculae have been made whenever possible. The drawings are 84 in number; and there are, in addition, 126 days recorded on which the surface was seen to be free from spots. A comparison of the several months shows a pronounced minimum of solar activity in December, with a near approach to it in July. Our magnetic records show also a marked minimum of disturbances in December, without any approach to it in July.

Work with the grating solar spectrometer has been in abeyance during the year owing to the absence of Father Cortie on the Government expedition to observe the total solar eclipse of April 28. But little or nothing has been lost: for there have been very few spots on the Sun large enough to work upon. A record of recent work with the instrument has appeared in the third volume of the *Transactions* of the International Union for Solar Research.

Of the many comets discovered during the year, those of Brooks, Quénisset, and Borrelly have been under frequent observation; and 16 photographs of the brighter one of Brooks (1911c) have been obtained.

Wolsingham Observatory (Rev. T. E. Espin).

The micrometrical measures of stars in the selected zones has been continued throughout the year. The examination of all the stars in Argelander, in zones $+54^{\circ}$, 53° , 52° , 51° , 50° (with the exception of a few stars), has been completed, and considerable progress has been made with zones $+49^{\circ}$, 48° , 47° . Certain gaseous stellar nebulae have been examined and connected by micrometrical measures with stars, where possible. The results have been communicated to the Society. The variable star R Cygni has been followed from minimum to maximum with the spectroscope. Nova Lacertæ has also been observed; it has slowly diminished to mag. 11.7, and still shows the nebular spectrum.

Mr. Newbegin's Observatory, Sutton, Surrey.

During the year 1911 observations for solar prominences, amounting to 70 in number, were made. 158 prominences were recorded, making an average of 2.2 per observation. The most striking prominence ($425''$) was observed on March 24, 22h. 45m.-23h. 30m., during an interval between snow squalls: it was very bright, and quickly collapsed, leaving only a small bright prominence $35''$ in height. For the remainder of the year nothing of note has been observed. Spots have been few and far between, and but little activity noted.

Rousdon Observatory, Devon.

(*Sir Wilfrid Peek's, Mr. C. Grover, Observer, in charge.*)

The exterior of the Observatory was repainted during the summer, and the electric light has been introduced. The equatorial has been renovated, and with the other instruments is in perfect working order. Weather was remarkably fine, and observations made on 152 nights. July, August, and September were the best months of the year. Observations of the long-period variable stars with the 6.4-inch Merz refractor equatorial were continued exactly as in former years, and 282 magnitudes were recorded, making a total of 11,469 magnitudes during the twenty-six years this work has been in progress.

Kiess' Comet (1911b) was observed on July 12, when it was quite a bright telescopic object, with a distinct nucleus and broad tail. It was observed on seven mornings in July, and at the end of the month was faintly visible to the naked eye.

Brooks' Comet (1911c) was picked up soon after its discovery on July 21, and was followed until October 11, when it was last

seen in the evening sky. After passing the Sun on the morning of October 25 it showed a tail, fully 20° in length, standing nearly vertical above the eastern horizon, after which it moved rapidly southward and soon disappeared.

Quénisset's Comet (1911f) was observed from September 26 to October 30. Toward the latter date it was a distinct telescopic object, with a faint tail.

Beljowsky's Comet (1911g) was a very elusive object; at 5 a.m. on October 5 it was quite distinct to the naked eye, with a fine spreading tail in the telescope. Moving rapidly toward the Sun it was soon lost, till after passing the Sun it was found with the equatorial telescope soon after sunset on October 21, and was seen for the last time on October 25 moving rapidly southward.

The conjunction of the planets Mars and Saturn at 3 a.m. on August 17 was well seen to the naked eye. Mars was decidedly the larger and brighter of the two. In the telescope it was seen this was an effect of irradiation, Mars being only 10" diameter, but much brighter than Saturn, whose diameter was 17".

Observations with the transit instrument have been frequently taken for the regulation of the sidereal clock, which maintains a steady rate.

Rev. T. E. R. Phillips's Observatory, Ashted, Surrey.

The instrumental equipment has been increased during the year by the loan from the Society of the very fine 8-inch Cooke equatorial that belonged to the late Mr. W. Coleman, and the addition of a new Standard Sidereal Clock by Lupton.

The 12 $\frac{1}{4}$ -inch Calver equatorial has been used for the study of the planets, the measurement of double stars, and observations of comets. The 8-inch Cooke has been employed for observations of Mars, but will in future be devoted primarily to double star measurements.

The meteorological observations have been continued.

Mr. Reynolds' Observatory, Harborne, near Birmingham.

The past year has been occupied in the completion and erection of a 28-inch reflector and a dome of 24 feet diameter.

The mounting of the reflector has been designed on the same lines as the 30-inch reflector of the Helwân Observatory, with the improvements and additions which have been found necessary in that instrument. The mirror is of 10 feet focal length.

A spectrograph by Hilger, specially designed for use on comets and nebulae, forms part of the equipment.

Mr. Saunder's Observatory, Crowthorne, Berks.

The principal work of the year has been the publication of the results of the measurement of six photographs of the Moon giving the plans of 2885 points. This appeared as vol. lx., part 1, of the *Memoirs* of the Society.

Kodaikámal and Madras Observatories.
(Director, Mr. John Evershed.)

Mr. C. Michie Smith, C.I.E., retired from the Directorship on January 13, 1911, but remained on special duty connected with the new electric installation until March 31.

Mr. Michie Smith has directed the affairs of the Kodaikámal Observatory since its foundation in 1899, and it was largely owing to his administrative ability and foresight that the Observatory was started on a satisfactory basis and with substantial buildings well adapted for the purposes in view. The electric installation now almost completed is entirely due to his initiative. This important addition to the equipment will greatly enlarge the general scope of the research work, besides affording increased facilities in many directions.

Mr. Thomas Royds, D.Sc., joined the staff of the Observatory as Assistant-Director in February.

The year as a whole was somewhat less favourable for solar observations than is usual, and there were no less than 27 days when no observations were possible.

Photoheliograph.—Direct photographs of the Sun on a scale of 8 inches to the diameter were taken with this instrument on 324 days.

Spectroheliograph.—Monochromatic photographs of the Sun's disc in "K" light were taken on 325 days, and prominence plates on 280 days. The position angles and heights of all the prominences shown have been measured and compared with the drawings made visually in H α .

Duplicates of the disc plates have been sent to the Solar Physics Observatory, South Kensington, for measurement, as in former years, and in exchange prominence plates have been received from South Kensington.

A new autocollimating spectroheliograph, constructed in the Observatory workshop, has been completed, and this was brought into regular use on April 1. With this instrument photographs of the Sun's disc in H α light were obtained on 165 days. The principal features shown on these plates are drawn by projection on the 8-inch charts used for recording sun-spots and prominences, and the heliographic positions are read off from the ruled lines on the charts. The H α absorption markings have been found by Mr. Royds to be very closely associated with the prominences.

Grating Spectrograph.—High-dispersion solar spectra have been photographed whenever the conditions permitted, and the special lines of research which have been prosecuted include the following:—

1. Radial and other movements in spots.
2. Pressure in spots.
3. Motion of calcium vapour in spots, in flocculi, and in undisturbed regions of the photosphere.
4. Motion in the line of sight of prominences, for determining the angular speed of the Sun's rotation at different heights above the photosphere.

Large spots were too few in number to admit of much progress in regard to radial motion effects, but a few plates have been obtained and measured. It has been found that whilst the outward radial motion appears to be an invariable and necessary accompaniment of spot formation, the inward movement of the higher levels is absent in the case of some spots showing very intense calcium emission.

Mr. Royds has obtained and measured about 50 plates of the H and K lines at the centre of the disc in undisturbed regions, for estimating the vertical movements of circulation of calcium vapour. His results in general confirm those of St. John at Mount Wilson in showing a general ascending movement of the emitting gas, and a descending movement of the high-level absorbing gas; but the values obtained in kilometres per second are considerably smaller than the Mount Wilson determinations.

The measures of wave-length of K_2 in flocculi do not indicate any ascending motion, as was anticipated, but on the contrary give evidence of a slight descending movement relative to the iron vapour of the reversing layer. A sharp distinction must therefore be recognised between the larger masses of emitting vapour known as flocculi, and the small bright points all over the disc which show an ascending movement.

The H and K lines in the prominences have been measured in over 60 plates, and the average angular velocities obtained show a large excess over the corresponding velocities found by Adams for the chromosphere, which itself rotates faster than the general body of the Sun. The excess is greater for the east limb than for the west.

Visual Observations.—Sun-spots and prominences have been observed and recorded as in former years. This work includes detailed records of affected lines in spot spectra, and bright lines in metallic prominences. The visual and photographic records of prominences extending over eight years have been studied with reference to the relative frequency on east and west limbs. A marked preponderance of eastern over western prominences has been found for each year, indicating an apparent influence of the Earth on prominence formation analogous to that found by Mrs. Maunder for sun-spots.

Comets.—Photographs were obtained of the spectra of comets 1911 *b* (Kiess) and 1911 *c* (Brooks) with an objective prism spectrograph. Direct photographs of these objects were also secured.

Publications.—Bulletins Nos. xxiii. and xxiv., dealing with the prominences of 1910, were published during the year, also papers dealing with the following subjects:—"On the Angular Speed of Rotation of a Long-enduring Prominence," "The Autocollimating Spectroheliograph of the Kodaikānal Observatory," and "The Absorption Markings in H α Spectroheliograms."

The meteorological and seismological observations were continued as in former years.

At Madras the chief astronomical work was the maintenance of the time service.

Adelaide Observatory, South Australia.

(Director, Mr. G. F. Dodwell, Government Astronomer.)

Various improvements to the transit-circle have been completed during the year. These include ball-bearing collars at the ends of the axis of rotation to replace the antifriction rollers; ball-bearings to end pressure plates; adjustable reading glasses to facilitate reading the micrometers; improved system of illumination for the circles; edges of circles engraved so as to read declinations direct with low-power eyepiece, replacing the old setting circles; geared slow motion to facilitate moving the telescope in zone by microscope reader; impersonal micrometer, etc. Several of these alterations have been based upon designs and suggestions kindly proffered by Mr. W. E. Cooke, Director of the Perth Observatory. The impersonal micrometer attachment was constructed by the University mechanician, Mr. Rogers, and the other alterations were effected by Messrs. Dobbie of Adelaide. It is intended to take up the systematic observation of *étoiles de repère*, in the zone -20° to -30° , and a list of the Fundamental Stars in that zone has been kindly supplied by Dr. Hough of the Cape Observatory. A list of "intermediates" is being sent by M. Lagrula of the Nice Observatory, and routine observations will be commenced when these are received. In the meantime investigations of the instrumental errors are in progress.

The system of time distribution has been carried on as heretofore. In the absence of an automatic return signal from the Semaphore Time-Ball Station, the falling of the time-ball has been observed from the top of the observatory tower with a small telescope, and the time of falling has been recorded on a chronograph in the transit-room. A lag of 0.3 second has been discovered by this means, and is now allowed for. An extension of the time-ball service to Port Pirie and Wallaroo has been recommended by the Marine Board.

In February 1911, the longitude of the Todd-Smalley Obelisk near the 141st meridian on the northern bank of the river Murray was re-observed by order of the Government, for purposes of evidence in connection with the Disputed Boundary Case, which was then before the High Court. The Boundary Station was connected telegraphically with Sydney, Perth, and Adelaide Observatories, and some fine sets of clock signals were interchanged, the Boundary and observatory clock-beats being distinctly recorded through a circuit 2000 miles in length. The Almucantar method of observing was used at the Boundary, and also by Mr. Cooke at the Perth Observatory, Mr. Curlewis observing with the Perth Transit-Circle. Personal equation was afterwards determined at the Adelaide Observatory between Messrs. Cooke, Dodwell, and Browne (the latter having been the observer at Adelaide), and finally between Messrs. Cooke, Raymond, and Dodwell at the Sydney Observatory on the return of the Eclipse Expedition from Vavau.

The Director represented the Adelaide Observatory on the Australian Eclipse Expedition to Vavau in the Friendly Islands, April 28, 1911, and had charge of a 16-inch Coelostat, kindly lent by the Royal Astronomical Society, and of two 12-inch parabolic mirrors belonging to Mr. Dobbie of Adelaide. These were used in combination, producing a $2\frac{1}{4}$ -inch image of the Sun by reflection on a screen in a photographic "camera obscura." Several interesting photographs of the lower corona were obtained, and an opportunity was afforded of studying the corona on the photographic plates during totality, as the plates were fixed on a stand without dark slides. Photographs of the partial phase of the eclipse were also taken. A resident of Vavau, Mr. Gaffney, who acted as interpreter for the party, assisted with these instruments on the day of the eclipse.

The Milne Seismograph has been continuously at work during the year, and tabulated records are being sent to Professor Milne. Assistance has been rendered to Messrs. Kidson and Webb, of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, in furtherance of this portion of their magnetic survey of Australia; and instruction in methods of obtaining latitude and longitude, and in the use of astronomical instruments, was given to some of the members of Dr. Mawson's Antarctic Expedition prior to their departure from Adelaide.

Public visits have been made to the Observatory every Friday evening, and lectures on astronomy at country institutes have been continued.

A welcome addition to the Staff was authorised during the year.

Perth Observatory, Western Australia.
(Director, Mr. W. Ernest Cooke.)

Meridian Observations.—During the first months of the year the regular series of zone observations was temporarily suspended, in order to clear up a few arrears of computation and to prepare vol. v. for the printer. The work was recommenced on June 18 with the zone 37° – 39° , and has been continued steadily.

Vol. v., containing the catalogue of the *étoiles de repère* in zone 35° – 37° , was put through the press, and is now ready for distribution, a few advance copies having already been posted. With the completion of the zone now in hand, vol. vi. will finish the first unit of the meridian programme, viz. the secondary standards and *étoiles de repère* for the region of the Astrographic Catalogue allotted to Perth, zone 31° – 41° south declination.

Astrographic Catalogue.—The new series of photographs for catalogue plates on the lines indicated in the last report (lxxi. p. 312) has been continued. During the year the whole of the zone with plate centre at 32° has been completed, and fair progress made with other zones. Measures and computations of plate constants are now sufficiently advanced to justify the commencement of printing, and during the year three volumes, comprising 18^h in R.A. of zone 32° , were placed in the printer's hands. Vol. iv. has already been distributed, and vols. i. and ii. are nearly ready. Vol. iii. has just (Jan. 1912) been passed on to the printer, and thus the whole of the first zone will probably be distributed before July 1912.

Time Service.—The time-ball at Fremantle failed on twenty-two occasions, all failures being due to faults on the line, or causes beyond the jurisdiction of the Observatory. Otherwise it dropped regularly at 1 p.m., or at such other hours as were required by the chief harbour-master. The mean error was $\pm 0^s.09$, and the mean of all recorded times $0^h 59^m 59^s.99$.

The other portions of the time service worked satisfactorily, and an additional public convenience has been arranged. A clock in the Telephone Exchange is controlled by the standard time clock at the Observatory, and any telephone subscriber is now entitled to obtain correct time by merely ringing up the Exchange and asking for it.

Boundary Determination.—In connection with the disputed boundary between South Australia and Victoria, the Government Astronomer, at the request of the South Australian Government, visited the eastern States in order to assist in the redetermination of the position of Todd's obelisk near the river Murray. Mr. Curlewis took the necessary transit observations in Perth, and transmitted signals to Adelaide, Boundary, and Sydney on twelve nights.

Total Eclipse of the Sun.—The Government Astronomer visited

Sydney and Vavau in connection with the Australian expedition to observe the total solar eclipse in April. Further particulars of this expedition will be found in the report of the Australasian Association for the Advancement of Science.

The following is a summary of the work done during the year:—

Plates completely measured in direct and reversed positions	109
Number of stars measured	41,632
" " Catalogue plates taken	333
" " Pritchard plates taken	51
Nights on which time was determined	187
Observations of clock stars in R.A. between June 18 and December 29	906
Observations of zone stars in R.A. between June 18 and December 29	3625
Observations of zone stars in N.P.D. between June 18 and December 29	3630
Separate determinations of Collimation error	4
" " level "	130
" " azimuth "	115
" " nadir point	52

Popular Astronomy.—Applications for permission to visit the Observatory at night, and receive some little instruction in popular astronomy, have become so numerous that it has been found advisable to purchase a new instrument, in order to relieve the pressure on the astrograph, the only equatorial. Accordingly a 12½-inch reflector, with clock work, etc., has been obtained from Calver, and the Public Works Department has just commenced (Jan. 1912) to provide the necessary shelter shed, etc. It is intended to make a strong feature of this service, and to hold public receptions at least twice a week throughout the year.

Sydney Observatory.

Mr. W. F. Raymond, Officer in charge.

During the year 1911 weather conditions were most unsatisfactory for observational purposes, in all 73 per cent. of the available nights were unfit for the work, and this amount of cloudy weather has been verified from the records of the Weather Bureau. Advantage was therefore taken to push forward with the computations for the Astrographic Catalogue.

The Transit Meridian Circle has been continually in use on

Dallmeyer lens which is to be permanently fixed on the astro-telescope.

Mr. P. P. Olden has had charge of the time service, and, with the assistance of Mr. Cranney, has carried on the transit work.

642 visitors have registered their names during the year, of whom 88 attended during the evenings for lectures on celestial objects.

The most important astronomical event during the year was the total solar eclipse on April 29 last. The line of central shadow passed through the island of Vavau, Friendly Islands, and four parties proceeded there to make observations. This observatory was represented by the officer in charge, Mr. W. E. Raymond, who was attached to the party led by Dr. W. J. S. Lockyer of the Solar Physics Observatory, South Kensington, England, and by Mr. J. W. Short, who joined Mr. Worthington's party. Unfortunately owing to heavy clouds the party under Dr. Lockyer did not succeed in obtaining satisfactory observations, whereas Mr. Worthington, who was camped two miles further north, had an uninterrupted view and succeeded in obtaining 30 photographs of the phenomenon.

The positions of Government Astronomer and Astronomical Assistant, which became vacant in 1908, have not yet been filled, but steps are now being taken to fill the vacancies.

Mr. Tebbutt's Observatory, Windsor, New South Wales.

In the astronomical department the only work done was the observation of position angle and distance of the most interesting of our southern binary stars. These will shortly be communicated to the Society. The usual meteorological observations were also carried out through the year.

Lovedale Observatory, South Africa.
(Dr. A. W. Roberts.)

During 1911 the prismatic 2-inch telescope by Cooke, the 1-inch theodolite by Troughton & Simms, and the $3\frac{1}{4}$ -inch telescope by Ross, have been employed in the observation of variable stars.

Stars brighter than the fifth magnitude were observed in a mirror which rotated the field through any angle.

The observations made during the year amounted to 2500, chiefly of long-period stars. Many southern stars have now been observed continuously at Lovedale for a period of twenty years.

The method of observation employed is that of Argelander.

*Transvaal Observatory, Johannesburg. (Director,
Mr. R. T. A. Innes.)*

9-inch Refractor (Mr. R. T. A. Innes).—A programme of double-star measurement was commenced in 1911: 396 pairs were measured satisfactorily on two or more evenings, and 8 new pairs were incidentally discovered. The results will appear in the Observatory Circular No. 13. 220 of these pairs were under 2" apart and 111 under 1".

The phenomena of Jupiter's four bright satellites were assiduously observed, and the results have appeared in Circular No. 12. The observations show that the time has come when more detailed predictions of the phenomena should be given: thus for J III and J IV, the times of commencement and end of each occurrence are wanted; the partial eclipses of IV and the partial transits and occultations of both III and IV should be indicated; thus the Ec.D. of III on 1911 April 29 occupied 19 minutes from first contact with shadow to extinction, whilst there is nothing in either Damoiseau's or Sampson's tables to indicate that the transit of III on 1911 April 4 would only be partial.

Comet 1911 (c) Brooks was observed for position on six occasions.

Franklin-Adams' Star-Camera (Mr. H. E. Wood).—The task of completing the charts for the southern hemisphere has been continued on every available occasion, but there are still a considerable number to be taken.

In answer to an appeal to the southern observatories to obtain photographs of the eighth satellite of Jupiter whilst Jupiter is in the southern hemisphere, a few plates were exposed here and measurable images were secured on two nights. As a bye-product, images of many minor planets, some of which were new, were found and measured. Some of the results obtained have been published in Circulars Nos. 8, 9, and 10. A few variable stars and nebulae were also brought to notice. The minor planets Hector (624) and 1911 MT were specially searched for; measurable images of Hector were secured on two nights (see *A.N.*, No. 4522), and a new planet 1911 MU was found near the place of 1911 MT, but so far MT itself has not been recognised. The places of the following comets were determined photographically:—

1911 b Kiess on twenty nights, Encke's on eleven nights.

Latitude-Telescope (2½-inch) (Mr. W. M. Worssell).—This has

been in constant use throughout the year. Late in 1911 some alterations were made in it on the recommendation of Dr. Albrecht; it is now possible to rotate the telescope 180° without lifting it from its V's.

Circulars Nos. 6 to 12 were distributed in 1911. Meteorological and seismological observations and the time service were continued on the usual lines.

To provide for the easier examination and more accurate measurements of plates, a stereo-comparator has been ordered from Messrs. Zeiss. The tower, roof, and moving floor are nearly ready for the 26-inch refractor, and the mechanical parts of the telescope are well advanced, but all attempts to cast crown and flint discs of sufficient size for the lenses of the object-glass have so far been unsuccessful.

NOTES ON SOME POINTS CONNECTED WITH THE PROGRESS
OF ASTRONOMY DURING THE PAST YEAR.

Discovery of Minor Planets in 1911.

Fifty new planets were discovered or first announced in 1911.

Letter and Number.	Date. 1911.	Discoverer.	Letter.	Date. 1911.	Discoverer.	Letter.	Date. 1911.	Discoverer.
LG	Jan. 31	H	MD	July 30	P	MV	Oct. 18	K
LJ 708	Feb. 3	H	ME	May 25	Wd	MW	18	K
LK 709	3	H	MF	Dec. 19 *	Ba	MY	18	K
LM 710	28	P	MG	Aug. 19	K	MZ	18	K
LN 711	Mar. 1	P	MH	19	K	NA	18	P
LO 712	19	Wf	MJ	24	K	NB	21	P
LP	22	Ma	MK	27	K	NC	21	P
LQ	23	Wf	ML	27	K	ND	21	P
LS 713	Apr. 18	H	MM	27	K	NE	29	Wf
LU	22	I	MN	28	K	NF	29	Wf
LW 714	May 18	H	MO	28	K	NG	29	Wf
LX	Apr. 22	Wd	MP	28	K	NH	29	H
LY	22	Wd	MQ	31	K	NK		
LZ	May 13	Wd	MR	Sept. 2	K	NL	Nov. 22	Me
LZ ^a	24	L	MS	29	P	NM	22	Me
MA	June 19	BE	MT	Oct. 3	P	NN	26	Me
MC	May 25	Wd	MU	16	K			

* 1908.

The initials stand for:—Ba=Prof. Barnard (Yerkes); Be=S. Beljawsky (Simeis, Crimea); H=Herr Helffrich (Heidelberg); I=Mr. Innes (Johannesburg); K=Herr Kaiser (Heidelberg); L=Prof. Lowell (Flagstaff, Ariz.); Ma=Herr Massinger (Heidelberg); Me=Dr. Metcalf (Winchester, Mass.); P=Dr. Palisa (Vienna); Wf=Prof. Wolf (Heidelberg); Wd=Mr. Wood (Johannesburg).

The following planets, not numbered at the date of the last report, have since received permanent numbers. In the case of 692 the first HD, discovered in 1901, is meant; in all the other cases the second assignment of letters is referred to:—HD 692, HN 693, JA 694, JB 695, JJ 696, JO 697, JX 698, KD 699, KE 700, KN 701, KQ 702, KT 703, KU 704, KV 705, KX 706, LD 707, LJ 708, LK 709, LM 710, LN 711, LO 712, LS 713, LW 714. JH, JK, JM, JP, JQ, JS, JT, JU, JZ, KA, KB, KC, KF, KG, KH, KJ, KK, KL, KO, KP, LA, LG, LP, LQ are not numbered.

The following planets have been named :—689 Zita, 694 Ekard, 696 Leonora, 703 Noemi, 710 Gertrude.

The following identities have been established :—LE=379 Huenna; LF=586; LH=333 Badenia; LL=489 Comacina; LR=109 Felicitas; LT=158 Coronis; LV=519 Sylvania; MB=471 Papagena; MX=533 Sara; NJ=480 Hansa. LJ is identical with the planet 1892 S, which did not then receive a permanent number.

Of planets discovered before 1911 :—JR prob.=120 Lachesis; JV=JO=697; JW=389 Industria; KM=335 Roberta; KS=474 Prudentia; KY prob.=580; 1905 PX=1909 JE=517 Edith; 1906 WV=495 Eulalia; 1911 MD=1906 UN^b; 1901 GZ=613; 699 prob.=1902 KQ.

699 has a very interesting orbit, the most eccentric planetary orbit known. The following are Dr. Berberich's elements :—

Epoch and Osculation 1910 June 21^o, Berlin M.T.

$$\left. \begin{array}{l} M = 324^{\circ} 45' 24'' \\ \omega = 88^{\circ} 43' 12'' \\ \Omega = 243^{\circ} 59' 48'' \\ i = 15^{\circ} 13' 12'' \end{array} \right\} 1910^{\circ} \quad \begin{array}{l} \phi = 24^{\circ} 21' 28'' \\ \log a = 0.417219 \\ \mu = 839''.804 \\ \text{Period} = 4.225 \text{ years} \end{array}$$

Perihelion distance 1.536. Aphelion distance 3.691.

The planet will probably only be observable at oppositions near perihelion. Dr. Berberich gave an ephemeris for January 1912 in *Ast. Nach.* 4537, but as the computed magnitude was only 15.5 its recovery before 1914 is doubtful.

Herr M. Brendel gives in *Ast. Nach.* 4544 the principal perturbations based on the above orbit; the two largest terms in longitude have periods of 61 and 14.7 years, amplitudes of $1^{\circ}.13$ and $0^{\circ}.42$.

624 Hector was observed last July both at the Cape and Johannesburg, with the aid of an ephemeris prepared by M. Braae, from revised elements by Professor Strömgren. His elements are given, together with those of the other three members of the Jupiter group. Patroclus was observed last year; it is in longitude Jupiter -60° , the other three are in longitude Jupiter $+60^{\circ}$. Achilles has not been observed since 1907, or Nestor since 1909. This has presumably been owing to their great south declination, but they are now coming north again.

Number	588.	617	624	659
Name	Achilles	Patroclus	Hector	Nestor
Computer	Bidschof	Heinrich	Strömgren	Ebell
Equinox	1910 ^o	1910 ^o	1910 ^o	1908 ^o
Epoch and osc ⁿ .	1907 Ap. 15.5	1907 De. 14.0	1907 Mar. 9.0	1908 Mar. 23.5
M	80° 18' 12"	73° 1' 25"	346° 3' 38"	240° 38' 5"
ω	125 37 50	302 25 48	175 6 42	327 31 28
Ω	315 36 1	43 28 36	341 58 57	349 57 42
i	10 18 25	22 3 15	18 8 34	4 31 15
ϕ	8 42 54	8 14 38	1 56 46	6 23 59
μ	293''.464	300''.532	293''.159	300''.785
$\log a$	.719668	.714644	.721936	.714500

The planet MT promised to be a most interesting object, as it was advancing pretty rapidly in Right Ascension when discovered, though almost exactly opposite the Sun. Unhappily moonlight and cloud prevented further observations for a few days, and afterwards all efforts to recover it proved unavailing. Consequently our knowledge of it is limited to the following three positions, obtained by Dr. Palisa and Herr Pechüle:—

G.M.T. 1911				Place.	App. R. A.			Log	App. Dec.			Log
d	h	m	s		h	m	s	Fact. Par.	°	'	"	Fact. Par.
Oct. 3	13	49	3	Vienna	0	42	5'15	9'440	0	15	37'6	N. 0'814
4	9	44	20	,,	0	43	43'30	9'043 ⁿ	0	12	48'9	S. 0'816
4	13	20	41	Copenhagen	0	43	59'0	9'270	0	17	49	S. 0'862

The fact that the second and third observations were on opposite sides of the meridian enables us to get an approximate value of the distance from the Earth; a distance of 0.18 will make the motion in R.A. uniform when reduced to the centre of the Earth. If we suppose MT to have a perihelion distance the same as that of Eros, an orbit slightly more eccentric than his with an inclination of some 7° will satisfy the observations. It has, however, been suggested that, though planetary in appearance, it may be moving in a parabolic orbit, and this would certainly make it easier to understand the rapid falling off in light which would seem to have taken place, from the failure to recover it in the middle of October, even with portrait lenses covering a large area. It is to be feared that it will remain one of the unsolved enigmas of astronomy.

433 Eros will be in opposition next July; this opposition is midway between the favourable ones of January 1894 and January 1931, and in consequence it is the most unfavourable one possible, being at aphelion. Dr. Witt gives the following elements:—

Epoch and Osculation 1912 July 30.0, Berlin M.T.:

$$\begin{array}{ll}
 M = 185^{\circ} 6' 45''.7 & \phi = 12^{\circ} 53' 13''.1 \\
 \omega = 177^{\circ} 46' 41''.1 & \mu = 2014''.88535 \\
 \Omega = 303^{\circ} 35' 22''.9 & \log a = 0.1638375 \\
 i = 10^{\circ} 49' 41''.2 &
 \end{array}
 \left. \begin{array}{l} \\ \\ \\ \end{array} \right\} 1910.0$$

The values of μ have been steadily diminishing by some 0.03 yearly. In the forecast of the most favourable oppositions of the century (vol. lxi. 4, p. 241) 2015''.255 was adopted, which is too great, the mean value being about 2015''.06. This alteration improves the conditions in 1931, making the interval between the Earth's and planet's passage through the longitude of planet's perihelion 6.4 days instead of 7.6. That of 1938 will be 9.4 days instead of 8.0. The opposition of 1924 is the next

tolerably favourable one, but it is distinctly inferior to that of 1900.

Ast. Nach. 4498 contains an investigation of the perturbations of Eros, by H. Samter. The principal Earth terms are:—

	Period. y
$-703'' \cos (79_{\text{Eros}} - 49_{\oplus})$	40.6
$+212'' \sin (37_{\text{, ,}} - 21_{\text{, ,}})$	82.6
$+148'' \cos (37_{\text{, ,}} - 21_{\text{, ,}})$	82.6

These, especially the long-period ones, are very sensitive to errors in the assumed mean motion, which is taken as $2015''\cdot 0$.

The *Berliner Jahrbuch* has altered the shape in which it prints details of planetary positions. Approximate ephemerides (each consisting of four positions at 10^{d} intervals) are given for 563 planets; that is, practically all of those that are in opposition in 1912, for which sufficiently accurate elements are available. The year of the last observation is also given, so that it is easy to see which planets specially need observing. For the majority of the planets perturbations are not applied, but the orbits will be empirically corrected from time to time by the observations. Perturbations are applied in the case of orbits of special interest (14 in the present year). Professor Berberich has published approximate tables for the positions of 307 planets: they give the quantities $r \cos$ latitude and $r \sin$ latitude for every 10° of heliocentric longitude, also the first date in the twentieth century when the planet passed each position. Herr M. Brendel gives some further tables in *Ast. Nach.* 4545 for facilitating the computation of the position of planets.

Professor Lowell has an article in *Astr. Jour.*, No. 630, on the librations of planets of the Hilda type whose period is about $\frac{2}{3}$ of Jupiter's. He concludes that their mean motions do not pass through the critical value which would make the commensurability exact, but go through small oscillations, remaining always on the same side of the critical value.

A. C. D. C.

Comets of 1911.

The observations of three comets seen in 1910 were prolonged into the following year. Of these three, Halley's was observed at Helwân up to May 18, and at Yerkes, at Lick, and at the Flagstaff Observatories till the beginning of June. Metcalf's, discovered August 8, 1910, was followed up to the beginning of May, and the periodic comet of Faye was seen at Algiers as late as March 1911. The number of comets discovered during the

year, including the periodic comets whose positions could be indicated with more or less precision, is no less than eight.

Comet (a) 1911 is a return of Wolf's periodic comet of 1884. It was found at the Heidelberg Observatory by Dr. Max Wolf on June 19, when it was described as a very faint object of the fifteenth magnitude. An ephemeris had been computed by Dr. Kamensky, of which the error at the time of discovery was scarcely more than the error of observation. The comet will not be in perihelion till February 24, but at that time will be too near the Sun for observation. The elongation from the Sun has not been favourable for observation. At present the comet sets about two hours after the Sun, and as the year advances even this interval will be curtailed. So far as is known, observations ceased last December.

Comet (b) 1911 was discovered by Mr. Kiess of the Lick Observatory on July 6. This comet was a comparatively bright object; with very small optical power a tail could be seen. It became visible to the naked eye and was very generally observed. Its motion carried it rapidly southwards, and it disappeared from European observatories early in August, at a time when it was still fairly bright. Observations, both spectroscopic and for position, have been very general. Further observations from the southern hemisphere are much to be desired, because the orbit has some resemblance to that of Comet 1790 I. Some deviation from a parabolic path was disclosed by the northern observations, but this might be explained by the difficulty of seeing the comet distinctly at a low altitude and in moonlight. It is, however, to be noticed, as tending to disprove any connection, that there is a considerable disparity in the longitude of the node; and since the inclination of the comet is large, this element is likely to have been determined with accuracy in 1790, and to have suffered small perturbation since.

Comet (c) 1911, discovered by Mr. Brooks of Geneva, U.S.A., on July 20, like the last, was also visible to the naked eye, and became a very conspicuous object in the morning sky. Its path was also southwards, rendering it invisible to European observers in the latter end of November. Observations of physical changes and of position have been numerous. Dr. Doberck, observing in England, states that the comet displayed the peculiarity of subdivision of the nucleus. On September 24 no nucleus was visible, on October 1 two nuclei were distinctly separable, but on October 6 the separation was considerably reduced. Accurate and interesting observations of the spectrum were made by Dr. Bělopolsky at Pulkova. Photometric estimations of the brilliancy were made by several observers. M. Esclangen, observing at Bordeaux, witnessed an occultation of the star B.D. + 40° No. 4503 by the comet. For some twelve seconds it was impossible to separate the nucleus of the comet from the star. The light of the two objects was completely blended, but the centre of the comet may have passed one or two seconds of arc to the north of the star. The brilliancy of

the star was thought to diminish very sensibly whilst the star and nucleus were inseparable. The light of the star did not apparently increase that of the comet, but, on the contrary, it appeared to diminish, recovering its brilliancy after separation.

Comet (*d*) 1911, a reappearance of Encke's comet, first detected by M. Gonnessiat on July 31, at Algiers. The observation was exceedingly difficult from the fact that, owing to the near approach of sunrise, the comet had to be observed only three degrees above the horizon. The comet was fairly bright, much brighter than might have been expected from the 1908 report: allowing for the unfavourable position in which it was seen, probably as bright as a star of the seventh magnitude. This observation, and one on the following morning, displayed a greater discrepancy between the predicted and the observed places than was probable, considering the care bestowed on the preparation of the ephemeris. Complete agreement was not expected, since the 1908 observations had not been accurately represented, the deviations pointing either to an increase in the assumed mass of Mercury or a decrease in the acceleration of the comet's mean motion. The disagreement here, however, was far greater than could be explained by such minute quantities. Dr. Crommelin pointed out that apparently a clerical error had been made in forming the excentricity used in the osculating elements for 1911, and Professor Backlund, in an interesting note, has admitted the accuracy of this suggestion. Having computed an ephemeris from the corrected elements, the observations made at Algiers before the perihelion passage (August 24), and in South Africa and at Santiago after that date, are represented with great accuracy. Professor Backlund is therefore able to decide, in a preliminary and cautious way, that the observed disagreement in 1908 is to be explained by a further diminution of the acceleration of the mean motion, and cannot be ascribed to an erroneous value of the mass of Mercury. This planet's mass cannot differ much from 1/9,700,000, and though it is probable that the decrease in the acceleration took place about the time of perihelion in 1904, this point cannot be definitely set at rest till 1914, since three consecutive returns are necessary to afford an independent determination of the acceleration.

Comet (*e*) 1911, the return of the Comet of Borrelly discovered in 1905, was first announced from the observatory at Helwân on September 19, and independently detected by M. Schaumasse on the same night at Nice. The ephemeris had been prepared by M. Fayet, who, owing to the uncertainty of the mean motion, had calculated the position on the assumption that the perihelion might be in error by four days in either direction. The correction needed, however, did not much exceed half a day; and since the comet had been observed at the 1905 return only, the result is very gratifying, the more so as the perturbations were very heavy, accelerating the return some three months. At the time of discovery the comet was in considerable southern declination, but was travelling northwards, and when nearest the Sun and Earth

in December became a fairly easy object. This comet is still under observation.

Comet (*f*) 1911, discovered by M. Quénisset at Juvisy on September 23, and independently by Mr. F. Brown of Lee, Kent, was another bright comet. It had been conveniently situated in our skies for some months previously, being for the greater part of the time circumpolar in Central Europe. At the time of discovery it was moving southwards and was lost to northern observers early in November, when it was fairly conspicuous. Just as the orbit of Kiess' Comet had some resemblance to that of 1790 I, the elements of Quénisset approach those of 1790 III. The agreement in this latter case is even more marked, but probably the similarity is accidental, and both will ultimately prove parabolic.

Comet (*g*) 1911, a fine naked-eye comet, was discovered on September 28 by M. Beljowsky, and independently by several observers in California, but too near the Sun to make a good display. It was first visible in the morning sky, but towards the middle of October was seen in the evening, when, notwithstanding the low altitude, the tail could be traced for some six or ten degrees. When last seen the comet presented the appearance of a condensed nucleus, from which extended two luminous jets with well-defined contours curved to form a parabolic arc, the branches being extended some four or five minutes from the nucleus. The observations in the northern hemisphere did not extend beyond the end of October. The comet can still be observed south of the equator. The orbit is probably parabolic.

Comet (*h*) 1911, the last cometary discovery of the year was announced by M. Schaumasse on November 30, who described it as a faint object of the twelfth magnitude. Observations are still in progress. The orbit will apparently present some interesting points. The early observations, embracing, of course, a very small arc of anomaly, gave for a parabolic orbit the date of perihelion passage 1912, February 5. An elliptic orbit based on a longer arc gives the perihelion passage November 12, 1911, and indicates that the comet has a period of about seven years.

In addition to this list, Dr. Franz of Breslau announced that on July 22, while looking for Kiess' Comet, he saw a nebulous object with a rapid motion, which he believes must have been a comet near the Earth. The right ascension increased three minutes in six minutes of time, and the declination altered considerably. The object, which was of the seventh magnitude, and about six minutes in diameter, has not been seen since.

Barnard's Comet, of which the period is uncertain to about half a year, probably passed through perihelion in the autumn unnoticed. Similarly, Tempel's first periodic Comet, due at perihelion last October, could not be observed. The circumstances attending its return were very unfavourable. Brorsen's Comet has not been seen since 1890: it should have returned this autumn, supposing the elements to have remained sensibly unaltered. This comet must be regarded as lost.

Definitive elements of the following comets have been published during the year:—

Comet.	Character of the Orbit.	Calculator.	Authority or Source.
1823	Parabolic	A. Hnatek	<i>Ast. Nach.</i> , 4510
1859 (Tempel)	Hyperbolic	O. Klein	" " 4511
1886 I.	Hyperbolic	E. Redlich	" " 4477-8
1893 I.	Hyperbolic	J. Polak	" " 4513
1902 III.	Elliptical	Peek & Lindsay	<i>Ast. Jour.</i> , 625

W. E. P.

Solar Activity in 1911.

Sun-spots.—The falling-off in the solar activity, which was so marked a feature of the record for 1910, was even more strongly accentuated in 1911. In 1908 and 1909 the days upon which the Sun's disc was clear of spots were 6 and 4 respectively; in 1910 the register of spotless days had increased to 65, but in 1911 to 180. The groups of spots observed on the remaining days were mostly small and short-lived, so that the mean daily spotted area observed was less than one-fourth that found in 1910, less than one-tenth that for either 1908 or 1909. The distribution of the spots in latitude was quite in keeping with this diminution in their number and area; for, with one exception, all were in the equatorial zone lying between $+15^\circ$ and -15° , and the great majority were within 10° of the equator. The last phase of the present cycle seems therefore to have commenced, and the point of minimum must be near at hand.

So rapid a decline in this part of the sun-spot cycle is unusual; indeed there is no recorded case to furnish a complete parallel, or to indicate whether the minimum will be short and followed by a rapid rise to a high maximum, or long drawn out as a prelude to a slow rise to a feeble maximum.

The faculae, like the spots, showed a marked decline of activity in 1911, but as usual at this part of the cycle, the decline has been less in proportion and steadier in character than with the spots.

April supplied the chief spot-groups of the year, opening and closing with fairly important spots on the disc. Group 6938, a large composite spot, speedily breaking up into three components, appeared at the east limb on April 1 and was the largest spot of the year. Groups 6943, 6944, and 6945, three circular spots ranged along the same meridian, were first seen on April 23 and 24, and the last two persisted into May. July and December were the two quietest months, each of the remaining months being marked by the presence of one group of moderate size.

E. W. M.

Prominences.—The daily frequency of prominences during the year 1911, as deduced from the examination of 56 spectroheliograms taken on various dates between April 14 and September 29, is as follows:—

Northern Hemisphere	.	.	.	.	.	.	1.5
Southern Hemisphere	.	.	.	.	.	.	1.6
Total	.	.	.	.	.	.	3.1

The photographs used were taken in " K_{2-3} " (calcium) light by means of the spectroheliograph of the Solar Physics Observatory, South Kensington. The minimum height of the prominences taken into account was about 20".

The above numbers indicate a considerable reduction in total activity since last year, the distribution remaining fairly equal in the two hemispheres.

Owing to the small number of photographs available, no attempt has been made to apportion the activity to latitude zones. Activity at the poles, however, was practically non-existent.

In order to form a comparative, *though only approximate*, view of the state of prominence activity in 1911, similar data for previous years, deduced exclusively from South Kensington photographs, are given below:—

		1905.	1906.	1907.	1908.	1909.	1910.	1911.
N.	.	3.4	3.9	3.5	2.5	2.9	2.6	1.5
S.	.	3.0	2.6	3.9	3.1	2.7	2.5	1.6
Total	.	6.4	6.5	7.4	5.6	5.6	5.1	3.1

The sequence shows for 1911 a strong drop in prominence activity.

The most recent values available of the mean daily frequencies as deduced at the Kodaikānal Observatory from full data, both visual and photographic, show that the activity had continued to increase in 1910.

		1905.	1906.	1907.	1908.	1909.	1910.
N.	.	7.8	8.6	8.9	8.9	10.1	11.2
S.	.	7.8	8.2	10.7	10.0	10.2	11.1
Total	.	15.6	16.8	19.6	18.9	20.4	22.3

Certain prominence returns regularly communicated to the *Indian Monthly Weather Review* by the same Observatory for the months January to August 1911 indicate a considerable reduction in the frequency of prominences from that of the previous year.

The high value for the activity of prominences in 1910 at Kodaikānal is extremely interesting when compared with the very rapid fall in the Sun's spotted area for the same year. The prominence returns from Catania and the approximate values deduced at South Kensington appear in general to follow more

closely the variation in Sun's spotted area. All three concur, and differ from Kodaikánal, in showing 1907 as the year of highest activity to date.

	1905.	1906.	1907.	1908.	1909.	1910.
Sun's Spotted Area (Greenwich)	1191	778	1081	697	692	264
Prominence Frequency (Catania)	3'01	2'48	4'29	3'56	3'61	?

A large prominence covering 31° of latitude on the S.W. limb, and reaching a height of (3') 80,000 miles, was photographed at Kensington on June 28, 1911. One of the highest ever recorded at Kodaikánal was observed on April 21 (lat. -34° E. limb), ultimately reaching a height of 10', with a maximum velocity of ascent (photographic) of 87 km. per sec.

W. J. S. L.

Solar Research in 1911.

Sun-spots.—The Greenwich data for the years 1898 to 1909 have been examined by Schuster, for evidence as to the existence of the subsidiary sun-spot periods which he had previously deduced (*Proc. R.S.*, 85 A, 50). The period of 4'79 years was clearly indicated in each cycle by a separate peak in the curve of frequencies, and the observed times of maxima were in close agreement with those predicted. The period of 8'36 years, which appeared with considerable regularity between the years 1836 and 1887, however, has not since then shown itself. The three chief periods are sub-multiples of 33'375 years, and Dr. Schuster considers that the coincidence between this and the time of revolution of the Leonid meteorites deserves careful attention.

The possible influence of planets on the formation of sun-spots has been further investigated by Dr. Schuster (*Proc. R.S.*, 85 A, 309), and by Mr. Stratton (*M.N.*, lxxii. 9). Dr. Schuster's analysis to some extent suggests the reality of a planetary effect, but Mr. Stratton prefers to suspend judgment until further data are available. As to the nature of the action, Dr. Schuster points out that the gravitational effects of planets may be much increased if there is a layer surrounding the Sun in which gravitation is partly counterbalanced by radiation pressure; or the action may be purely electrostatic, depending upon the expulsion of negative electrons from the Sun, and the consequent positive electrification of the solar clouds, and negative electrification of the outer layers of the planetary atmospheres. Notwithstanding his negative results, Mr. Stratton is also of opinion that the dynamical effects of planets upon what may be an atmosphere of uncertain stability should be manifested in some of the solar phenomena; the present difficulty is to smooth out the effects of the more powerful forces which cause the great periodic outbursts of solar activity.

The Spectroheliograph.—The frequent apparent deflection of prominences by horizontal currents has been discussed by Slocum (*Ap. J.*, xxxiii. 108). Over 3000 large prominences were examined, and about one-third presented the appearance of being driven to one side by a wind. It results that in general the deflection of prominences in middle latitudes tends towards the poles, while in prominences of high latitude the tendency is towards the equator. These conclusions probably apply to an upper current analogous to the terrestrial anti-trades. In another paper (*Ap. J.*, xxxiv. 294) Dr. Slocum reproduces some fine photographs of an interesting prominence observed on October 10, 1910.

The angular velocity of a prominence of long duration (February 5 to April 28, 1910) was investigated by Evershed (*Ap. J.*, xxxiii. 1). There were four appearances on the west limb, three on the east, and three meridian transits as an absorption marking on the disc. It is considered highly probable that there was an intermittent production of prominences from a definite locality in the Sun, and that, while the place of origin rotated with the normal speed of the photosphere, the prominences partook of the greater velocity of the chromosphere and drifted westward. It is noted further, that while dark markings on the disc are almost invariably represented by prominences when they reach the limb, the majority of large prominences seem to produce no absorption when on the disc.

A new spectroheliograph of the autocollimating type which has been erected at Kodaikānal has been described by Evershed (*M.N.*, lxxi. 719). The instrument is specially intended for photographs in H_{α} , and some preliminary results have been described by Dr. Royds (*M.N.*, lxxi. 723). The velocities of rotation of some dark filaments were found to differ considerably, but the mean value was apparently somewhat greater than that for sun-spots, in accordance with the view that the absorption is produced at a relatively high level.

A preliminary investigation of the angular velocities of the K_3 filaments has also been made by Deslandres and D'Azambuja (*Comptes Rendus*, cliii. 442). The velocity was found to be very variable, but in the majority of cases was greater than that at lower levels. From meridian transits the velocities of filaments between 0° and 30° were found to be constant and equal to that of equatorial spots. Deslandres has suggested that these variations, and certain other prominence phenomena, may be due to the action of a solar magnetic field (*C.R.*, clii. pp. 1281, 1433, 1541, and clii. pp. 10, 221).

Details as to the positions, heights, and areas of prominences photographed at Mt. Wilson and Yerkes Observatories during the period 1906 June to 1908 November have been published by G. Abetti and Miss R. E. Smith (*Ap. J.*, xxxiii. 141). Data for prominences recorded visually and by the spectroheliograph during 1910 have been tabulated by Evershed (*Bull. Kod. Obs.*, Nos. 23 and 24).

Some splendid examples of the spectroheliograms taken at Meudon are given in the completed edition of vol. iv. part 1 of the *Ann. de l'Obs. d'Ast. Phys. de Paris*, which was first presented in an incomplete form by M. Deslandres at the Mt. Wilson conference of the Solar Union. Valuable suggestions relating to the interpretation of the phenomena are included.

The Corona.—The polarisation of the light of the solar corona as observed at the eclipses of 1901, 1905, and 1908 by the Lick Observatory expeditions has been discussed by R. K. Young (*Lick Observatory Bull.*, 205). The polarisation was found to be radial, and to reach a maximum of 37 per cent. at five minutes from the limb. It is concluded that the corona is formed by matter which has been projected from the Sun.

Professor J. A. Miller has investigated the theoretical forms of coronal streamers on the supposition that they are the projections on a plane of streams of particles, the motion of which is produced by ejection, by the rotation of the Sun, and by the radiant pressure of the Sun (*Ap. J.*, xxxiii. 303). Corresponding forms have been found on photographs of the corona.

The structure of the corona has also been considered by C. Störmer on the supposition that the magnetic field surrounding the Sun is the same as it would be if due to a magnet lying along the axis of rotation, and that charged particles are constantly expelled normally from the Sun's surface. (*C.R.*, clii. 425.) The resulting trajectories show considerable similarity with the coronal rays at sun-spot minima.

Some interesting experimental work which may aid in the interpretation of the corona has been carried on by Birkeland. By using a magnetised globe as cathode in a large discharge vessel, a distribution of luminosity which has some resemblance to that of the corona has been obtained (*C.R.*, clii. 345, cliii. 456). The experiments also suggest a possible explanation of the zodiacal light and the Gegenschein.

The Sun's Rotation.—An important memoir giving a detailed account of the observations and reductions of solar rotation photographs taken at Mt. Wilson has been prepared by W. S. Adams and Miss Lasby, and published by the Carnegie Institution. Many of the results have been stated previously, but it may be mentioned that the observations are all satisfied by a law of rotation in which the velocity increases, and the equatorial acceleration decreases, with increasing distance outwards from the Sun's surface, the cause of this probably lying in the effects of friction in the lower portions of the solar atmosphere. In order of decreasing acceleration we have spots and faculæ, calcium 4227, calcium flocculi, and H_α, while the reversing layer shows a greater amount of equatorial acceleration than any of these.

The visual determinations of the Sun's rotation, commenced at Edinburgh by Halm, have been continued by photographic

methods, and an account of the work has been given by J. Storey and R. Wilson (*M.N.*, lxxi. 674). Nine solar and eleven telluric lines were measured. The results show small systematic differences as compared with other determinations, but, like the Mt. Wilson investigations, they show no certain evidence of a periodic variation in the rotation.

Circulation of Calcium Vapour.—Dr. St. John has extended his investigations of the motion of calcium vapour in the solar atmosphere so as to include regions over spots and flocculi (*Ap. J.*, xxxiv. 57 and 131). It was found that in the umbrae of spots the calcium vapour producing the emission line (K_2) was in general descending, while in the penumbrae there was usually no vertical motion. Over flocculi a small ascending movement of 0.23 km. per sec. was found for the emitting vapour, against an upward velocity of 1.97 km. over the general surface; this result is not in agreement with the general assumption that over flocculi this vapour is rising rapidly from the interior of the Sun or from a hotter lower stratum. The conditions obtaining in the case of the upper calcium layer (giving K_3) are the same over the general surface, the faculae, and the region immediately surrounding the faculae, namely, a descending motion of 1.14 km. per second.

In this connection attention should be drawn to two further papers by Dr. Julius (*Proc. Roy. Acad. Amst.*, March 23, May 26, 1911), in which it is maintained that the peculiarities of the H and K lines can be explained without admitting the ascending and descending motions to which the phenomena have been attributed by St. John.

A possible explanation of the "double reversals" of H and K by anomalous dispersion has also been given by Professor Bevan (*M.N.*, lxii. 84), who points out that on this view measurements of the positions of the components of the lines could not give the velocity of the vapour in the line of sight.

A theoretical discussion of the possible effects of changes of density or refractive index, and of transverse movements of the absorbing gases, in producing displacements of spectral lines has been given by A. Cotton (*Ap. J.*, xxxiii. 375).

Solar Radiation.—A further discussion of the bolometric observations made on Mt. Wilson and Mt. Whitney has led Abbot and Fowle to conclude that the mean value of the solar constant of radiation for the period 1905-9 was 1.922 standard calories per sq. cm. per minute. It is considered that this represents within one per cent. the intensity of the solar radiation which would have been indicated by a standard pyrheliometer situated in free space at the Earth's mean distance from the Sun. (*Ap. J.*, xxxiii. 191.)

In another paper (*Ap. J.*, xxxiv. 197) Mr. Abbot has dealt with the Sun's energy spectrum, and temperature, as determined from observations between wave-lengths 0.30μ and 3.0μ . The maximum

of energy falls at 0.470μ , and Wien's formula gives the effective solar temperature as 6230° C. absolute. With the previously mentioned value of the solar constant, Stefan's formula for total radiation gives the temperature as 5830° C. absolute. Reasons are given for considering that even the higher estimate must be too low, and that the true value of the Sun's effective temperature is of the order of 7000° C.

In a criticism of the work of Abbot and Fowle (*Ap. J.*, xxxiv. 371), F. W. Very maintains that the absorption of the incoming solar rays has been underrated, and that the most probable value of the solar constant is not less than three, nor more than four calories. It is stated that a solar constant of this order accords with the data of meteorology, and harmonises a great body of facts which would otherwise be found to be in conflict.

Solar and Terrestrial Phenomena.—The view that a terrestrial magnetic storm may be caused by a swarm of electrified corpuscles ejected from a limited region of the Sun has been quantitatively discussed by Schuster (*Proc. R.S.*, 85 A, 44). The result is regarded by Dr. Schuster as conclusively proving that magnetic storms cannot be due to a direct magnetic action of such swarms of electrified particles. It may be, however, that the particles act by increasing the ionisation of the outer regions of the atmosphere and allowing the electromotive forces which are always present locally to increase the intensity of the electric circulation; the rotation of the Earth, which is the primary cause of the electromotive forces which come into play, then becomes responsible for the energy. The view that the impact of the projected particles causes luminosity remains allowable, so that Birkeland's theory of the aurora borealis is still tenable.

An analysis of the Berlin temperature records from 1756 to 1907, and of the precipitation records from 1848 to 1907, in relation to the sun-spot period, has been made by O. Meissner (*A.N.*, 4533). The comparisons appear to indicate that the years of spot maxima were relatively cold and wet.

Miscellaneous.—In connection with an investigation of the spectrum of the rare element dysprosium, Dr. A. D. Ross has found that the eight chief spark lines occur in the chromospheric spectrum. Dysprosium accordingly follows the general rule that the enhanced lines of an element are the most prominent in the chromosphere (*M.N.*, lxxi. 671).

Attention may be called to the publication of the third volume of the Transactions of the International Union for Solar Research, giving a full account of the proceedings at the Mt. Wilson conference (Sherratt & Hughes, Manchester). A new book on "The Sun" by C. G. Abbot (Appleton and Co) should also be mentioned.

Double Stars.

The abbreviations used are —

M.N. : *Monthly Notices.*

A.N. : *Astronomische Nachrichten.*

L.O.B. : *Lick Observatory Bulletin.*

New Doubles and Measures of known Pairs.—In continuation of his systematic survey of the zone $+44^{\circ}$ to $+55^{\circ}$, the Rev. T. E. Espin publishes further discoveries, all in the zone $+48^{\circ}$ to $+55^{\circ}$; these bring Mr. Espin's total discoveries from 927 to 1125. These are in *M.N.*, January 1911 and January 1912. The separation ranges from $1''$ to $9''$, the magnitudes of primaries from 7.5 to 12.0, and of companions from 9.1 to 14.0. Mr. Espin employs a $17\frac{1}{4}$ -inch reflector.

Professor Aitken has also pursued his systematic search for new doubles with the 36-inch Lick refractor. He contributes 100 new doubles in *L.O.B.*, 188, and a further 100 in *L.O.B.*, 204, bringing his total discoveries up to 2400. Of the 200 now added, 52 are under $0''.5$ separation.

M. Robert Jonckheere (l'Observatoire de Lille), another observer making a systematic search for new double stars with a $13\frac{3}{4}$ -inch refractor, contributes his results in *M.N.* Supplementary number, November, December, and January. By these additions M. Jonckheere's number is now 709. Of the 294 now added, 63 are under $2''$ separation.

In the Southern Hemisphere double star work is taken up at the Transvaal Observatory, and Mr. Innes has devoted Circular No. 6 to three pieces of work. First, there is a contribution of 360 new pairs found by Mr. Innes with the 9-inch Grubb refractor. This makes 1060 new doubles discovered by Innes. Of the present list 280 are under $2''$ separation. Next comes 120 pairs discovered by Mr. Ward with a $9\frac{1}{2}$ -inch Cooke at Wanganu, New Zealand. Some of these Mr. Innes has identified as known pairs; but 102 remain as discovered by Mr. Ward. The third list contains measures of 41 stars having motion.

Mr. Roe, Syracuse, U.S.A., has new doubles in *A.N.*, 4467, and in *Popular Astronomy*, June, July, and November; and C. P. Olivier adds 24 new pairs in *L.O.B.*, 191. These were found with the 12-inch Lick. Ten are under $2''$ separation.

The Rev. T. E. R. Phillips, *M.N.*, January 1911, gives measures with a $12\frac{1}{4}$ reflector of 13 J. Herschel pairs, and 12 W. Struve. In the same issue the Rev. T. E. Espin ($17\frac{1}{4}$ -inch reflector) gives his eighth series of measures, consisting of 62 stars, mostly Herschel pairs rarely measured, ranging from $1''$ to $80''$ separation. A further set of measures useful for proper motion of faint stars is in *M.N.*, January 1912.

The measures of double stars within 40° of the N. Pole made at Edinburgh by J. Storey are in *M.N.*, March. These stars are

in general but little observed. The telescope is a 15-inch refractor. Of the 249 stars measured, 102 are under 2" separation. Another very useful piece of work emanating from Edinburgh is in *M.N.*, November, where Mr. Wrigley gives his measures of double stars found on the Astrographic plates taken at Perth, W. Australia, in 1903-4. Of these 17 are 3" separation, 80 between 3" and 5", and 192 over 5". Although some have been identified, no systematic attempt has been made.

The customary mean results of measures of double stars made with the 28-inch refractor at Greenwich are in *M.N.* Supplementary number. Of these 453 pairs are under 2" and 269 over 2" separation. The stars are from the catalogues of W. Struve, O. Struve, Burnham, Hough, Hussey, and Aitken.

In *L.O.B.*, 191, Mr. C. P. Olivier follows up his measures of southern doubles (*L.O.B.*, 175) by another set of 159 stars with the 12-inch Lick refractor. Of these 123 are under 2" separation.

In *A.N.*, 4464, Prof. Burnham publishes further measures made with the 40-inch Yerkes telescope. The principal object of observing these wide pairs, ranging from 5" to 3' separation, is to obtain material for improved proper motions of bright stars.

M. Lau, in *A.N.*, 4523, gives measures, made with the 10-inch refractor at the Urania Observatory, Copenhagen, of 62 pairs chosen in 1892 for measurement by Engelhardt as possessing large proper motions. M. Lau gives Engelhardt's measures and his own made 1910-11, and shows in a table the p.m. of both components.

Another set of measures for determining proper motions is in *A.N.*, 4490. These are by Abetti with the 38-cm. refractor of the Collegio Romano.

In *A.N.*, 4537, J. Voûte of the Leiden Observatory presents his second series of measures of Σ and $O\Sigma$ pairs. Of these 61 are under 2" separation and 61 over. The refractor has an aperture of 21 cm.

Measures of neglected Σ pairs are also found in *A.N.*, 4488. Of these 136 are by M. Lau, and a further 56 are by E. Buch-Andersen.

Dr. Doberck, in *A.N.*, 4479-80, 4507, and 4529, gives measures made at Sutton, 1909-10, of 500 pairs, of which 140 are under 2" separation. Some of the wider pairs are very useful, e.g., the two faint companions of σ Coronæ.

In *M.N.*, December, R. Jonckheere gives a set of measures in continuation of those published in the *Journal Astronomique* (Hem). These are for the most part his own discoveries and some Aitken pairs.

Another photographic contribution is by M. Lau in *A.N.*, 4541. These 66 pairs were photographed on special rapid plates by aid of the new photographic refractor at the Urania Observatory, Copenhagen. The free aperture is 162 mm., and focal length 3.301 m. The separation of these pairs ranges from 2".8 to

36".7. Each result is the mean of 4 measures, and M. Lau gives the probable error of these as

Separation.	p. e. (angle).	p. e. (dist.)
4" - 8"	± 0.15	± 0.028
8 - 12	.09	.024
12 - 32	.06	.021

The p. e. of the 2".8 pair is ± 1.13 and ± 0.068 .

"Mikromettermessungen von Doppelsternen am 32.5 cm. refractor ausgeführt in dem Jahren 1898-1909," von H. Struve, F. Cohn, A. Postelmann, und W. Hassenstein. These results are in the *Astronomische Beobachtungen auf der Königlichen Sternwarte zu Königsberg*, and are of pairs selected from the Σ and $O\Sigma$ catalogues as showing motion. Amongst them are good series, extending over 11 years, of η Cassiopeiæ, ζ Cancri, ξ Ursæ Majoris, ξ Boötis, η Coronæ, γ Ophiuchi, and δ Cygni. Of these pairs, 206 are under 4" and 100 over 4" separation, these latter consisting, in general, of the more distant companions of the close pairs measured—a most useful addition.

Computational and Theoretical Papers.—Professor H. N. Russell in the *Astrophysical Journal*, 1910 December, discusses the mass ratios of the components in the system Krueger 60. The magnitudes of the stars are, $A = 9.7$, $B = 11.0$, and $C = 10.2$. Prof. Russell finds that the mass of B is 1.14 times that of A. The parallax of the system is 0".25 and the p.m. 0".87. In the same paper Prof. Russell concludes that the apparent masses of the spectroscopic components of the visual stars in the system Castor are very small compared with the Sun's mass, and probably each is less massive compared with its visual primary than is the case in any other system yet investigated.

a_1 Gem. (spec. comp.), period 2.93 days, app. mass 0.0097 $\odot$.

a_2 Gem. " " " 9.22 " " " 0.015 $\odot$.

(This paper will also be found in *Popular Astronomy*, March.)

Herr Hertzsprung in *A.N.*, 4543, has a paper entitled "Über Doppelsterne mit eben merklicher Bahnbewegung," in which, by making certain assumptions, he arrives at values of parallax and absolute stellar magnitude. Thus, assuming a value for the sum of the two masses of the components of a fairly well-known binary, he shows it possible to compute an inferior limit for the parallax. A comparison, in the case of 25 pairs, of the measured parallax with the hypothetical parallax leads him to consider that a value of the parallax, within one-third its value, can be obtained by doubling the hypothetical parallax. Again, from the parallax and apparent magnitude he arrives at the absolute stellar magnitude of 55 stars by the formula—App. star mag. + 5 log. minimum hypothetical parallax.

A useful paper containing the spectra of 762 double stars was

presented by Miss Cannon at the Ottawa meeting of the American Astronomical and Astrophysical Society.

In the *English Mechanic*, August 11 and August 25, the Rev. T. E. Espin discusses his own discoveries, and also the stars contained in "Katalog von Doppelsternen der photographischen Himmels Karte, aus der zone $+31^{\circ}$ to 40° Deklination," and in each case shows that the numbers of pairs decrease with increased separation.

"Ueber die Entwicklung der Doppelsternsysteme" is the title of a small brochure in which Dr. F. Nölke applies mathematical tests to the theory held by Dr. See and Dr. Russell, viz., that double stars, both visual and spectroscopic, owe their origin to the disruption of rotating nebulae. The result of his work tends to prove:

(1) The mass ratio of the parts originating in the disruption of a homogeneous rotating nebula does not exceed 3 : 1

(2) The initial orbital eccentricity is very small, and tidal friction is incapable of subsequently increasing this to such an extent as to account for the large eccentricities in the majority of double star orbits.

(3) The initial eccentricity does not exceed .04, and the maximum values as increased by tidal friction are only 0.38, 0.28, and 0.23, for $\frac{m_1}{m_2} = 3, 2, \text{ and } 1$.

(4) Only close double stars could have originated from disruption.

To restrict the cataloguing of double stars, Dr. Aitken formulated a scheme whereby no pair should, in future, be considered a "double star" unless it satisfied certain conditions dependent on magnitude and distance. In its original form most observers felt the limitations too severe, and more moderate criteria were formulated in *A.N.*, 4505. In this revised scheme two stars form a "double star," if when

<i>the combined magnitude is</i>	<i>the separation</i>
fainter than 11	does not exceed 1"
fainter than 9.0, B.D.	" " " 3"
between 6.0 and 9.0, B.D.	" " " 5"
" 4.0 and 6.0, B.D.	" " " 10"
" 2.0 and 4.0, B.D.	" " " 20"
brighter than 2.0, B.D.	" " " 40"

Papers bearing on the question will be found in *A.N.*, 4505, and *The Observatory*, No. 433.

T. L.

Variable Stars.

The year 1911 shows a steady advance in this department of Astronomy, both in discovery and research among known variables.

The total number of new variables registered provisionally by the committee of the *A.G.* for 1910 is 136; for 1911 the number extends to 88, up to the date of writing. (*A.N.*, 4545.)

A.N., 4540, contains a list of 148 variables to which permanent lettering has been allotted.

New Variables.—Harvard College Circulars Nos. 164, 165, and 167 announce respectively 5, 3, and 31 new variable stars, all discovered by the examination of photographic records of the sky.

Mme. Ceraski in the same way continues her discoveries of new variables, many being announced from time to time in the *A.N.*

In *A.N.*, 4518 E. Hertzsprung announces the variability of the Pole star (α Ursæ Minoris). From a study of 418 photographic plates, variation has been detected with an amplitude of 0.171 m.; elements, max. J.D. 2418985.856 *d.* + 3^d.9681 E. The star therefore belongs to the short period class of variables, with light curve of δ Cephei type. It is possible, change of colour is also involved; in that case, the change in actual magnitude may not be over 0.1 m.

In *A.N.*, 4532, T. H. Astbury announces provisionally that the star B.D. + $58^{\circ} 30'$ (7.3 m.) is variable, the change being possibly of the Algol type.

Nova.—Harvard College Observatory Circular No. 164 announces the discovery of Nova Sagittarii No. 4, found in the examination of photographs by Miss Cannon. So far as the plates go, it was brightest in 1901 May 22, 10.3 m. It was not visible on April 10 of that year. After maximum its light faded and fluctuated somewhat after the style of Nova Persei No. 2 of 1901.

Nova Lacertæ.—Many observations of this object, which was discovered by the Rev. T. E. Espin at the end of 1910, have been made. One of the latest is by E. Jost with a wedge photometer on 1911 May 7, when the star was 9.98 m. M. Luizet gives a light curve which shows a rapid decline to the middle of February, after which the descent is more gradual. Professor Barnard finds from photographic records that this Nova had existed as a 14 m. star for at least seventeen years previous to its outburst. On August 12 S. Kostinsky found on a photographic plate an aureola surrounding the star, similar to that observed round Nova Persei, 1901. M. Wolf has published an excellent photographic chart of the vicinity. (*A.N.*, 4466, 4468, 4470, 4493.)

Special studies, or observations of established variables.—In *M.N.*, lxxi. 6., Prof. E. T. Whittaker and C. Martin have published a light curve of the short period variable RW Cassiopeiæ, based entirely on photographs. The curve has been analysed harmonically, and a formula indicates the various minor fluctuations in the light

curve. The agreement generally between the curve and photographed magnitudes is good.

Professor Whittaker has also published a preliminary paper on the law governing the variations of SS Cygni, based on the work of the var. star section, *B.A.A.*, and observations of L. Campbell. The brightness may be represented by a sum of sine and cosine terms, the most important of which has a period of 45.3 *d.* The author intends in a subsequent paper to complete the curve of periods, a work which will be looked forward to with much interest, seeing that hitherto the variations of SS Cygni have been considered as capricious and subject to no law. (*M.N.* lxxi. 8.)

In *Ap. Journal*, xxxiii. 3, A. W. Roberts studies the variation of the short period variable S Aræ, which he considers is due to (1) intrinsic light change in one of the component stars, and (2) an eclipse cause. The light curve shows a stationary period, followed by a rapid rise to maximum and a rapid descent. The stationary phase lasts for 2 h. out of a period of 10^h 50^m 43^s.45. A diagram of the system is given, from which we learn that it consists of a central star of radius 0.772, of constant brightness 10.61 m., and a satellite star of radius 0.177 revolving round the central star, and constantly varying as it revolves through the rarefied envelope of the primary. The advancing hemisphere is greatly more luminous than the following, this being due to the amount of atmosphere driven off it. The maximum brightness occurs before the star reaches quadrature.

In *Ap. Journal*, xxxiv. 2, A. W. Roberts deals with the spectroscopic binary κ Pavonis, period 9.09106 *d.* The fundamental curve seems to be of a smooth character, with a curious secondary phase or minimum superposed on the rising branch, between minimum and principal maximum. This is due to the partial eclipse of the secondary star by the primary.

In *Pop. Ast.*, xix. 1, J. Stebbins describes a method of determining the brightness of stars with a selenium photometer. This has been applied to Algol, with the result that a secondary minimum of less than 0.1 m. is indicated, a feature never brought out by visual work.

In *C.R.*, 1911 January, M. Luizet puts forward the following hypothesis in explanation of the δ Cephei type of variation. The maximum and minimum brightness are produced as the luminous body passes through the ascending and descending nodes. The luminous body is spherical, and from some cause that portion of the body which is in advance, in its orbital motion, is rendered more luminous than that which is behind.

In *Pop. Ast.*, xix. 7, P. R. Sutton gives an excellent summary of recent researches into this same type of stellar variation. The author concludes that the question is still an open one, and one that will probably furnish material for investigation for many years.

Among other investigations, the following may be referred to:—
The Theory of Algol type Stars, by E. Zinner. *A.N.*, 4476.

Photometric observations of Mira Ceti (1909-1911) made at Catania with a wedge photometer, by A. Bemporad. *A.N.*, 4506.

Study of variation of α Herculis, from which a light-curve of β Lyræ type is deduced, by E. Hertzsprung. *A.N.*, 4526.

In *A.N.*, 4544 and 4545, two new variables (or ? novæ) are announced, from photographic plates, by C. R. D'Esterre of Tatsfield, Surrey.

The star discovered by A. R. Hinks at Cambridge (var. 97.1910) has been observed by Prof. E. E. Barnard, who states that it is only a variable, and must go through at least five magnitudes. *M.N.*, lxxi. 6.

A.N., 4538, contains a paper on the Distribution of Variables in the Sky, by E. Zinner. Charts are given, also an analysis of the periods of 724 stars.

General.—In H.C.O. Circular No. 166, Professor E. C. Pickering writes on the subject of co-operation in observing variable stars. The principle has been adopted in the variable star section, *B.A.A.*, for over twelve years now. To avoid unnecessary duplication of work, and consequent waste of power, Prof. Pickering would make the co-operation more or less international. The object is to study closely the changes in well-known variables by bringing to bear on them a large, but not unnecessarily large number of observations. A list of 372 variables is given, showing the separate observers known to be watching each, so that anyone taking up a share in the work may see where his energies may be best directed.

At the International Congress of Official Astronomers held at Paris in 1911, October 23-26, to arrange for co-ordination in the work of the various offices engaged in the preparation of national astronomical ephemerides, it was decided to include ephemerides of Variable Stars in the *Berliner Jahrbuch*. E. E. M.

Stellar Distribution and Drift.

As there was no report on this subject last year, the present note covers the two years 1910 and 1911.

Stellar Distribution.—The general problem of stellar distribution involves three main questions: (1) The luminosity law—in what proportions do the stars of different degrees of intrinsic brightness occur in a given volume of space? (2) How does the density of distribution of the stars at different distances from the Sun compare with the density in our immediate neighbourhood? (3) How much absorption of light in space is there? There are in addition many questions of detail in the structure of the stellar system, but the three enumerated above seem to be the most pressing. So long as there is an important divergence of view on these matters, the whole scale and character of the stellar system will be in doubt. The data for solving these questions are

principally the statistics of the number of stars of different magnitudes, the mean parallactic motion of different classes of stars, and thirdly the meagre but highly important information supplied by the directly measured parallaxes. Various aspects of this problem are touched on in a number of papers in the *Ast. Nach.*,—Seeliger (No. 4359), Kapteyn (4388-9), Schwarzschild (4422), Hertzsprung (*ibid.*), Lau (4430), and Comstock (4472). Lau, from observations of the fainter components of double stars, which are not physically connected systems, has found a remarkably small parallactic motion of the tenth magnitude stars, and has deduced that their mean parallax is $0''.001$, about a quarter of the value generally assigned. This conclusion is criticised by Comstock. The other papers mentioned above are technical, and are concerned with the numerical expression of the distribution laws of luminosity and density. Attention may be specially called to Schwarzschild's paper, which gives a very elegant solution of the difficult equations which occur in this problem.

Charts exhibiting the distribution of globular star-clusters and the different types of nebulae (spiral, planetary, and other gaseous) are given by A. R. Hinks (*M.N.*, lxxi. pp. 538, 693). The distribution of the globular clusters is very remarkable, for with very few exceptions they are contained in one hemisphere of the sky. As regards the spiral nebulae, their well-known aggregation towards the galactic poles appears to be part of a general, though less marked, concentration towards a certain belt at right angles to the galactic plane.

The distribution of variable stars is investigated by E. Zinner (*Ast. Nach.*, 4538); they show a rather strong concentration towards the galactic plane.

Stellar Motions.—The search for faint stars with large proper motions on the Oxford chart-plates is concluded by F. A. Bellamy in the fifth of a series of papers (*M.N.*, lxxii. p. 65). In the whole work about 30,000 stars were examined, and of these 392 were found to have proper motions of over $15''$ per century.

The publication of Professor Boss's *Preliminary General Catalogue* has provided a new and improved basis for research as to stellar motions, and has greatly stimulated investigation in this branch of astronomy. Simultaneously the researches of Kapteyn, Frost, and Campbell have shown that there is a progressive increase of the haphazard individual motions of the stars, for the later types of spectrum as compared with the earlier; thus a new peculiarity of star-motions is revealed, the relation of which to the star-stream phenomenon is still very obscure. In particular it has been found that stars of the helium type of spectrum seem to stand apart, and do not belong to either of the two great star-streams. The whole subject of "stellar distribution and movements" was discussed at the meeting of the British Association, 1911: the paper introducing the discussion, which summarises the present state of our knowledge, is printed in the *Report* (abstract in *The Observatory*, 1911 October). It was there suggested that

the great distance of the helium stars might account for the fact that they did not conform to the two star-streams, for the phenomenon of star-streaming might not extend to the very remote parts of the stellar system, where the helium stars are thinly scattered. J. C. Kapteyn (Amsterdam Akad., 1911 November 25) has investigated this possibility. He finds evidence that the two star-stream system is not confined to the nearer parts, but it extends to those remoter parts of space, which contain at least 40 per cent. of the observed helium stars; he concludes that the above suggestion for the exceptional behaviour of these stars is accordingly untenable.

L. Boss (*A.J.*, 612, 614, and 623) discusses the proper motions of stars of his catalogue. He finds for the solar apex the position R.A. $270^{\circ}5$, Dec. $+34^{\circ}3$. By considering the relations of the individual stellar motions to the parallactic motions, he was able to confirm the progressive increase in individual velocity with later type of spectrum; his results agree well with those found from the radial motions. From a paper by B. Boss (*A.J.*, 629), it appears that L. Boss has also made an investigation using the two star-stream hypothesis. His results for the apparent directions of motion of the two star-streams are respectively R.A. $95^{\circ}6$ Dec. $-7^{\circ}5$ and R.A. $289^{\circ}9$, Dec. $-54^{\circ}0$. The details are as yet unpublished.

From the same proper motions, A. S. Eddington (*M.N.*, lxxi. p. 1.) has found the directions of motion of the two streams to be R.A. $90^{\circ}8$, Dec. $-14^{\circ}6$ and R.A. $287^{\circ}8$ Dec. $-64^{\circ}1$ respectively, and their velocities to be 1.52 and .85. The stars were found to be divided between the two drifts in the proportion 3:2. The most significant deviation from the exact mathematical two-drift distribution was an excess of proper motions directed nearly towards the solar antapex. J. Halm (*M.N.*, lxxi. p. 610) considers that this extra stream (with which the helium stars appear to be closely associated) is of equal importance with the other two streams, or rather that the stream I of former investigations is really constituted of two streams, one of which is directed towards the solar antapex. He has accordingly made an analysis of Boss's proper motions on a three-stream theory, and obtained an improved accordance between theory and observation. The stars streaming towards the solar antapex are strongly concentrated in the galactic plane. H. A. Weersma (*Ap. J.*, xxxiv. p. 325) has investigated and confirmed the fact pointed out by Dyson that stars of Type I diverge much less from the general stream directions than those of later types. Assuming that the drift velocities are the same for all, Weersma's result shows that the individual velocities for Type I are only half those for Types II and III; but there is some indication of a change in the drift-motion as well as in the individual motions as we pass from Type I to Type II.

A partial confirmation of the existence of star-streaming has been found in the radial motions by Halm (*M.N.*, lxxi. p. 610) and by Campbell (*L.O.B.*, No. 196). For other investigations depending on the radial motions, which have an important bearing

on the present subject, see the Council Notes on Stellar Spectroscopy for this year and last.

Another result from the proper motions of Boss's Catalogue is the detection by three investigators simultaneously of two groups of stars of the helium type, which form "moving clusters," *i.e.* have nearly equal and parallel motions (Kapteyn, *Internat. Union of Solar Research*, iii. p. 220; B. Boss, *A.J.*, 620; Eddington, *M.N.*, lxxi. pp. 39, 43). One of these is spread over a large area in Scorpio and Centaurus; it is somewhat difficult to define its limits. The other consists of about seventeen stars in and near Perseus; it is well-defined and differentiated from the non-cluster stars. Both clusters have a motion of about 4" per century (which seems to be mainly parallactic); this is rather larger than the average motion of the helium stars.

P. Stroobant (*Bull. Astronomique*, xxvii. p. 433) has given a list of seven bright stars, which are suspected of belonging to a solar cluster, as their motions are similar to that of the Sun. The evidence of connection between these stars (which in some cases are very remote) is, however, not very conclusive. A. S. E.

Stellar Parallax.

Two important series of researches on Stellar Parallax have been recently published, *viz.*, *Determinations of Stellar Parallax*, by Henry Norris Russell (published by the Carnegie Institution), and *Photographic Determinations of Stellar Parallax* made with the Yerkes Refractor, by Frank Schlesinger (reprinted from the *Astrophysical Journal*). Mr. Russell came to Cambridge as an Advanced Student in Astronomy; he was then appointed a Research Assistant of the Carnegie Institution, and Sir Robert Ball made him an honorary member of the Cambridge Observatory staff, with a view to his working with the Sheepshanks Equatorial (Coudé type).

Mr. Arthur Hinks and Mr. Russell together planned the Astrographic observations and methods of measurements. The observations were made jointly from 1903 till the autumn of 1904, when Mr. Russell fell seriously ill; the work at the telescope was then carried to completion in 1907 by Mr. Hinks. Mr. Russell is alone responsible for the actual measurement of the plates, their reduction, and the discussion of the results.

Professor Schlesinger's work is based on Astrographic plates taken with the great 40-inch Yerkes refractor from June 1903 to June 1906.

In both series the chief sources of possible systematic error, *viz.*, (1) "Guiding Error" and (2) "Hour-Angle Error," have been recognised and steps taken for their elimination.

The first of these errors arises from the fact that it is impossible

to keep the images of the stars exactly stationary upon a plate. But although all the images wander together on the plate, only the brighter stars would record excursions of short duration from the mean position, and consequently the exact *locus* of the ultimate record of any image will, to some extent, depend upon its intensity. To damp down the effective light of the parallax star to equality with the mean photographic magnitude of the comparison stars is therefore the obvious plan to eliminate guiding error.

At Cambridge, in the plate-holder, directly in front of the sensitive plate, a screen of clear optically worked parallel glass was inserted, upon the centre of which, on the surface next the photographic plate, is a small patch of gelatine stained with a yellow dye. This damps down the photographic brightness of the central (or parallax) star by rather more than 6 magnitudes—and all stars brighter than 5th magnitude were photographed with such a colour-screen.

At Yerkes, mechanical methods were adopted for damping the light of the parallax star. In the first experiments a shutter of about 4 cm. in diameter was employed—operated by a tube and hand bulb. This shutter was opened for a few seconds at a time, at intervals symmetrically timed during the whole exposure. The developed plate showed excellent images for the parallax star, in no way distinguishable in appearance from those of the comparison stars. But on measuring four plates (each with three exposures) taken in this way, the probable error of the position of the parallax star relative to the comparison stars proved to be three times as great as that in plates where the parallax star was originally of the same magnitude as the comparison stars. This experiment proved conclusively that when the parallax star is brighter than the comparison star, the damping of the former to equality of intensity with the latter should be automatic and continuous.

Accordingly a rotating disc with an opening of variable aperture (after the fashion of an Abney disc-photometer) was mounted in front of the photographic plate, and rotated 6 or 8 times a second by a belt over a pulley connected with a small electro-motor. The two halves of this disc can be rotated with respect to each other and then clamped, leaving a clear sector of any angular aperture up to 180° . Thus if the angular aperture is 36° , only one-tenth part of the total light-energy of the star would reach the plate, and the apparent magnitude of the parallax star would be reduced by 2.5 magnitudes. The angular aperture of the disc necessary to reduce the apparent magnitude of the parallax star to that of the mean magnitude of the comparison stars was ascertained for each region by careful preliminary experiment. This method was found to be applicable to reductions of 7 magnitudes, corresponding to an angular opening of little more than 0.5° . The images thus obtained "showed no trace of diffraction effects due to the revolving discs, and their measurement proved to be as accurate as upon unobstructed images of fainter stars."

To eliminate the hour-angle error the simple expedient was

adopted, both at Cambridge and Yerkes, of making all the observations as nearly as possible at the same hour-angle for both parallax epochs.

In heliometer observations it has been shown, both at the Cape and Yale, that the observer unconsciously *superposes the same colour* when "crossing through" the two short star spectra (formed by chromatic dispersion of the atmosphere), and thus systematic errors dependent on difference of the refractive index of the mean light of the stars under observation are automatically avoided. But this is not the case in photographic observations. Indeed, in the method of "damping" the light of the parallax star which was adopted at Cambridge a difference of refraction-constant is necessarily *created* by partial colour absorption of the screen, and this would certainly give rise to very considerable systematic error if the observations at positive and negative parallax epochs were made at different hour-angles. At Cambridge all the plates were taken very near the meridian. At *loc. cit.*, p. 37, a table is given where the mean hour-angle of the morning and evening observations (t_1 and t_2) and the corresponding parallax factors (p_1 and p_2) are given for each plate. The average value of $(t_1 - t_2)$, regardless of sign, is 7.3 minutes of time, the maximum is 27 minutes. Thus the hour-angle error must be restricted within very narrow limits; the mean value of $(p_1 - p_2)$ is 1.40.

At Yerkes it was not practicable to limit the range of hour-angle so strictly, "for time with the Yerkes refractor is very precious," so that the observer did not wait till the next region came just to a certain hour-angle, but secured as many plates as he could, even though some were taken in extreme cases as much as two hours from the mean hour-angle. An effort was made, however, to keep the mean hour-angle of the morning plates equal to the mean hour-angle of the evening plates for any one region. In the printed tables the hour-angles are exhibited for each plate, and show at a glance how far this ideal condition has been attained.

On the whole, hour-angle error is more strictly eliminated in the Cambridge than in the Yerkes series.

It is otherwise, however, with the "guiding error." In the Cambridge observations only one colour screen was employed, and that only when the parallax star was brighter than 5th magnitude. There is thus frequently considerable difference between the intensity of the images of the parallax star and the comparison stars—and hence a considerable liability to guiding error.

Professor Schlesinger lays great stress on the necessity for complete equality in the images, and concludes that, for the best results, there should not be a greater difference than 0.2 or 0.3 between the ultimate photographic magnitudes of the parallax and comparison stars—an equality which he did not realise in his own practice, as he did not originally think it was necessary. But after completing his investigations he found (*loc. cit.*, p. 129) in the mean of 14 plates, in which the image of the parallax star is

nearly of the same intensity as those of the comparison stars, the average probable error from one plate is $\pm 0''.0184$; whereas from 14 series where the photographed image of the parallax star is considerably brighter than the comparison stars, the average probable error is $\pm 0''.0336$. For the six series in which the rotating disc was employed to reduce the brightness of the parallax star, the probable error for one plate was only $\pm 0''.0202$. Whence he concludes that *measurements upon images whose diameters have been reduced by the use of the disc are practically as accurate as those made upon correspondingly faint stars*; and that in future he would use the disc in every case.

In the case of the Cambridge series, there were, as a rule, four exposures on each plate, instead of three as in the Yerkes series. The probable error of the relative place of the parallax star derived from a plate of unit weight (four exposures) is $\pm 0''.048$,* which contrasts not unfavourably with the average probable error of the Yerkes results, viz., $\pm 0''.026$, when one has regard to the great difference of focal length in the telescopes employed—viz., 19'3 feet at Cambridge and 63 feet at Yerkes. Roughly speaking, one Yerkes plate of 3 exposures is equivalent in weight to four Cambridge plates of 4 exposures each. Mr. Russell (*loc. cit.*, p. 71) gives an interesting table comparing the precision of the Cambridge plates, as measured by him, with that attained in other modern parallax-researches. The weight of a single Cambridge plate of 4 exposures is, on the whole, about equal to that of an average complete observation with the Cape or Leipzig Heliometers—the best of the Cambridge plates having weight equal to one of the best series of heliometer observations.

The Yale Heliometer observations have a lower accuracy.

The Bonn plates, taken by Kapteyn's methods and measured by him, are equal in accuracy with the best of the heliometer observations; those at Upsala have but half the weight of the Bonn observations; and Barnard's micrometer measures with the 40-inch Yerkes telescope have a weight about equal to the worst of the Cambridge photographs—or nearly three times the probable error given by an average photographic plate observation made with the same instrument.

Kapteyn's beautiful plan, viz., making exposures upon the same plate at three different epochs approximately six months apart, involves very special care in the identification and preservation of the plates and their adjustment in the telescope, in order that the later images may be conveniently placed with respect to the earlier ones; also the failure of the exposure at any one epoch renders the whole plate useless—a fact that is not revealed until all three exposures have been made and the plate developed;

* This is subdivided (*loc. cit.*, p. 71) into 3 classes, viz.—

Close double stars (in 10 series)	$\pm 0''.060$
All other stars (in 34 series)	$\pm 0''.044$
Perfect exposed plates, when magnitude of parallax star = that of comparison star	$\pm 0''.036$

and, in any case, it is necessary to wait at least a year after beginning the observations before any of the plates can be measured. There is the farther risk, as Kostinsky has shown, of a creeping or change in the film during the interval when the plate is undeveloped. These considerations have led both the Cambridge and Yerkes observers to adopt the plan of taking several separate plates at each parallax-epoch, and developing them at once.

Although the Yerkes object-glass is corrected for visual observation, it has been used for the photographic observations without a colour-screen. But Professor Schlesinger has found that Cramer Instantaneous Isochromatic plates act, to a great extent, as their own filters for the region $\lambda 4800$ to $\lambda 5200$, as they are only slightly sensitive to this part of the spectrum. They have a strong maximum at $\lambda 4500$, but light of this wave-length is so much out of focus that it is spread into a circle of about 2 mm. in diameter when it reaches the plate. For moderate exposures the only effective part of the spectrum in forming an image is included between $\lambda 5200$ and $\lambda 5700$ —a region that is all fairly in the same focus. If the exposure is prolonged, the brighter stars begin to show halos several millimetres in diameter, due to blue and violet light. But, for reasons already mentioned, it is essential in parallax work to avoid star-images of considerable difference in diameter or intensity, and to reduce the image of a brighter parallax star to equality with the images of the comparison stars. Such images, when not over-exposed in the Yerkes telescope, are so small and sharp that the components of a double star of 0".75 distance are separated.

The Taylor triple object-glass of the Cambridge Equatorial is so perfectly achromatic that the "image of a brighter star is quite free from the violet glare familiar in ordinary instruments, and its spectrum when observed with a direct vision prism over the eyepiece is linear through its extent." It is unfortunate that this otherwise admirable form of object-glass varies considerably in focus when there is a sensible difference between the temperatures of its three component lenses—"it was therefore necessary to determine the focal setting for every evening of observation, and sometimes to change it during the evening"; but so long as the focus remains sensibly constant during the exposure of a plate, this should not affect the accuracy of the results.

At Cambridge a *réseau* was impressed upon the plate, and the star-images were referred, as in the measurement of the international catalogue plates, to the adjoining *réseau* lines. In this way the effects of distortion of the film were limited to the distortion within an area of 5 by 5^{mm}. At Cambridge, as a rule, the x co-ordinates were alone measured, but when the parallax star has considerable parallax in declination the y coordinates were also measured.

At Yerkes no *réseau* was employed, because such small linear distortions of the film as occur in good photographic work would

probably have an almost insignificant effect when the scale of the photograph is as great as it is in the Yerkes telescope, viz., $1^{\text{mm}} = 10''\cdot6$. When the minor axis of the parallactic ellipse is small the displacement of the parallax star was measured along the direction of the major axis. But for stars of smaller ecliptic polar distances, where the minor axis of the parallactic ellipse is considerable, the usual x and y co-ordinates were measured (*i.e.*, the parallax in R.A. and declination).

The Cambridge photographs afford 55 determinations of the parallax of 40 stars or pairs of stars, and at Yerkes of 27 stars, of which the space at disposal does not permit the exhibition of the separate results; it must suffice to limit the list here given to those stars of which the parallaxes have been observed both at Cambridge and Yerkes.

	Cambridge.		Yerkes.		Helimeter.		Flint (Meridian Obs.).	
	π	p.e.	π	p.e.	π	p.e.	π	p.e.
(1) Groombridge 34	$+0''250 \pm 0''016$		$+0''266 \pm 0''010$		$C + 0''31 \pm 0''010$		$+0''31 \pm 0''034$	
Lalande 7443	$-0''011 \pm 0''014$		$+0''039 \pm 0''013$		$C + 0''04 \pm 0''040$			
Berlin A. 4999	$+0''105 \pm 0''024$		$+0''077 \pm 0''014$					
Lalande 25372	$+0''221 \pm 0''020$		$+0''152 \pm 0''007$		$E + 0''17 \pm 0''055$		$+0''43 \pm 0''065$	
W. B. 17th 322	$+0''095 \pm 0''016$		$+0''140 \pm 0''020$		$C + 0''13 \pm 0''010$		$+0''19 \pm 0''027$	
(2) Pos. Med. 2164	$+0''298 \pm 0''041$		$+0''282 \pm 0''003$		...		$+0''32 \pm 0''043$	
Lamont 18180	$+0''076 \pm 0''065$		$+0''060 \pm 0''012$					
Krüger 60	$+0''258 \pm 0''019$		$+0''252 \pm 0''006$					
Lalande 46650	$+0''211 \pm 0''015$		$+0''151 \pm 0''013$		$E + S + 0''185 \pm 0''016$		$+0''23 \pm 0''092$	
(1) Also, Auwers (equatorial transits) $+0''29 \pm 0''024$								
(2) Kostinsky (photography) $+0''29 \pm 0''021$; Lamp Eql. micr. $+0''353 \pm 0''014$								

The agreement of the results is on the whole satisfactory. Unfortunately in the Yerkes series no statement of the comparison stars employed is given, so that it is impossible to discuss how far the same comparison stars have been employed at Cambridge and Yerkes. It is to be hoped that fuller details will be ultimately published. Of the 47 determinations of parallax made at Cambridge in which the star is central and the weight of the parallax determination is over 1.5, only four are negative—and 9 out of the total 11 negative parallaxes are smaller than their mean errors.

When grouped with the argument "Computed Parallax," there is close systematic agreement with Kapteyn's formula. When grouped according to magnitude the observed parallaxes of the fainter stars are in excess, but they are in general accord with the formula when grouped according to proper motion. When grouped according to spectrum-type there is an excellent agreement for the mean of stars of the first type (O to F₅), but there is a marked division in those of the second type, viz., the observed parallaxes of types (F₈ to G₅) are strongly in defect of the formula, and those of K to M markedly in excess of it.

On the whole, the Cambridge results, when a sufficient number of plates have been taken, and when the comparison stars are symmetrically arranged, give results of an accuracy which, but for the wonderful precision of the Yerkes observations, would have been regarded as of the highest class. The anxious care and foresight employed to eliminate systematic error in these researches is a striking improvement on any work which has hitherto been done in England. It was at one time feared that the intervening plane mirror of the Cambridge Equatorial might create difficulties by flexure in different hour-angles, or by change of curvature from change of temperature; but, by careful mounting and use only at small hour-angles, the former source of error has been avoided, and apparently the latter has not produced obvious errors.

That such a large collection of parallax plates should have been made in a climate like that of Cambridge, when limited by the condition that they shall all be taken very near the meridian, is a high testimony to the untiring energy and enthusiasm of Messrs. Hinks and Russell.

In the case of the Yerkes results, Schlesinger gives a very crucial proof of their freedom from systematic error.

In the case of 9 stars, the parallax factor in declination was sufficiently great to give an independent determination of the parallax, and he gives a table of the differences between the values of the parallax independently derived from the displacements in these two co-ordinates. Five of these exceed the probable error and four are less than it.

Four stars of the Helium type were observed for parallax, viz. :—

C Persei	$\pi = +0''.008 \pm 0''.009$	ψ Orionis	$\pi = -0''.019 \pm 0''.015$
π^4 Orionis	$\pi = -0''.012 \pm 0''.007$	S Monocerotis	$\pi = -0''.007 \pm 0''.012$

The mean result is $\pi = -0''.006 \pm 0''.005$, so that these fourth magnitude stars are quite as distant as average ninth magnitude stars in the same regions of the sky.

The methods of observation, of measurement and reduction, are all satisfactorily described in both the works in question, and (which is of hardly less importance) the full reasons for each precaution adopted are explained. Want of space has prevented reference to other than the more important of these details.

The most careful previous consideration of every imaginable source of systematic error, and the provision of means for its automatic elimination alone render progress possible in that extreme refinement of micrometric research which nowadays is necessary for the extension of our knowledge of stellar parallax. It is important to note that every preconceived source of possible error has turned out to be a reality, and it has in every case been found desirable to refine on the precautions for its elimination in a degree not at first contemplated. Thus, for example, whilst Hinks and Russell were originally content to diminish the chances

of "guiding error" by a single colour-screen reducing the photographic magnitude of a star by 6 magnitudes, and employing this screen only when the parallax star is brighter than 5th magnitude, Russell comes to the conclusion that in future a variety of such screens should be used to equalise more perfectly the photographic magnitudes of the parallax and guiding stars*—and Schlesinger, who employed the rotating disc in six series only, writes: "In the light of present experience I should for similar work in future use the disc almost in every case."

With regard to hour-angle error, Schlesinger finds marked errors produced by a difference of 2 hours in hour-angle in the observations of a coloured star. In such researches it is not the parallax of a particular star, with reference to particular comparison stars, that is of the greatest importance, but the solution of the broad question, viz., What are the relative parallaxes of various classes of stars, differing in magnitude, proper motion, spectrum and position in the heavens? When one considers that the angles in question are so minute that they can only be determined from the means of large masses of observations, it is then only that the supreme importance of the most minute precautions for the elimination of systematic error can be fully realised. Hence the importance, *inter alia*, for preserving precisely similar hour-angle and other conditions of exposure at both parallax epochs.

Supremely important as is the elimination of every source of systematic error, the adoption of means to secure the minimum of accidental error is hardly less so when the minuteness of the parallaxes to be measured is considered. One essential for the latter purpose is the employment of telescopes of long focus, as is evidenced by the greatly superior accuracy of the results given by the Yerkes telescope. Schlesinger has shown that with a telescope of the size and character of that instrument "*the number of stellar parallaxes that can be determined per annum, with an average probable error of $\pm 0''.013$, will in the long run be about equal to the number of clear nights available for the work.*"

How great this advance is, only those who have determined parallaxes of like accuracy with inferior means can fully realise. It is improbable that other instruments of like power with the Yerkes telescope will be available in this generation—but it is not impossible that by greater stability of mounting, by greater perfection of clock movement, and improved equalisation of the images, by object-glasses specially corrected for photographic work, and by the production of sensitive plates with finer grain, an equal precision may be attained with smaller instruments.

There are now in course of construction for Johannesburg and Santiago de Chili telescopes of 26 and 24 inches aperture and 35 feet focal length, which ere long may be available for stellar parallax determinations in the southern hemisphere; and if effect is given to Dr. Backlund's proposals, now before the Duma, there

* It is understood that coloured screens of optically worked glass of considerable variety of absorption are now employed at Cambridge.

will be a similar telescope erected at Nikolaiev, which is to be exclusively devoted to this kind of research.

We may reasonably hope that in these excellent sites and with these highly refined instruments results little if at all inferior in accuracy to those of the Yerkes telescope will be attained.

A careful examination of the results of observations for stellar parallax by meridian transit observations does not afford much hope that results of like accuracy with those of Cambridge and Yerkes will be attained by that method, especially when they must include empiric corrections which are considerably larger than the parallaxes which it is sought to determine.

D. G.

Stellar Spectroscopy in 1911.

Nebulæ.—In attempts to determine the spectral type of the central star in the Ring nebula in *Lyra*, K. Burns (*L.O.B.*, vol. vi., No. 193) has photographed the nebula with a slitless spectrograph on the Crossley Reflector at Mount Hamilton. He finds evidence of 12 lines in the spectrum, and concludes that there is real connection between the central star and the nebula, as definitely as is the case with the central condensations of the small nebulæ N.G.C. 6572 and 7009. His observations do not completely agree with that of M. Wolf (*Vj.s Ast. Ges.* (1908), 43, 283) in reference to the differences between the various monochromatic images of the ring.

The study of the relation between the spectra of spiral nebulæ and star clusters has been continued by Fath (*Ap. J.*, 33, 58) at Mount Wilson, and some signs of evidence are found of a progressive change in the spectra with change of form of the nebulæ.

Nicholson contributes (*M.N.*, 72, 49) a striking paper on the spectrum of nebulium, deduced from considerations of a theoretical atom consisting of electrons revolving about a positive nucleus of relatively large mass. Extending the work of J. J. Thomson, Nagaoka, and Schott, he finds relations between the periods of disturbances set up perpendicular to the plane of rotation in a ring of revolving electrons. He then compares certain wave-length ratios between related periods with wave-length ratios between observed nebular lines in Wright's list. It is not yet possible to formulate a connection between the various sets of ratios, but the agreement between theory and observation is so marked as to encourage the hope that another large step has been taken towards a working atom, and astronomers will rejoice that their domain of science thus contributes to the advance.

Campbell calls attention to the interesting questions to be settled by observations for the determinations of velocity of nebulæ (*Ast. Nach.*, 188, 345), and Fabry and Buisson have shown

(*C.R.*, 152, 995, and *Ap. J.*, 33, 406) that interferential methods should afford precise measures of the wave-lengths of the hydrogen lines, and accordingly give the velocity of such objects.

Novæ.—The following references serve as a guide to information about the spectrum of Espin's Nova Lacertæ:—

Frost,	<i>Ap. J.</i> ,	33,	p.	410,	(photograph).
Wright,	<i>L.O.B.</i> ,	6,	No.	194,	(photograph).
Idrac,	<i>C.R.</i> ,	152,	pp.	173 and 302.	
Pickering,	<i>A.N.</i> ,	187,	p.	93	
M. Wolf,	„	187,	„	134,	(photograph).
Münch,	„	188,	„	17,	(spectrum intensity curves).
Stratton,	„	189,	„	159.	

The spectrum of the remarkable star P Cygni has been studied by Merrill at Mount Hamilton (*L.O.B.*, 6, No. 201). He confirms Belopolsky's identification of the lines of nitrogen (*Ap. J.*, 10, 319), and notes a curious unconformable shift of silicon lines. This star is specially notable as a Nova (1600) which still retains the characteristics of the early spectrum of novæ, and this suggests the idea that the conditions of the peculiar spectrum are not necessarily to be found only in the exciting circumstances of a collision or excessive tidal commotion.

Studies of Special Stars.—The H_{β} line in 25 *Orionis* is announced as having two bright components by Campbell (*L.O.B.*, 6, p. 153).

The spectra of a number of stars of the B and A types have been studied by Jordan with the single-prism Mellon spectrograph of the Allegheny Observatory (*Alleg. Pubns.*, 2, No. 12). Several have been found to be spectroscopic binaries, and the radial velocities of 26 others are published.

The radial velocity of R *Lyræ* has been deduced from 18 photographs by Z. Daniel in hopes of detecting variation in the period of 0.9796 day in the light-variation announced by Yendell (Daniel, *Alleg. Pubns.*, 2, No. 13; Yendell, *Astron. Jour*, 26, 139).

The spectra of *Sirius*, *Procyon*, and *Arcturus* have been photographed with the 60-inch reflector and a large single prism spectrograph at Mount Wilson by Adams (*Ap. J.*, 33, 64), on a scale of 1.4 tenthmetres per mm. at λ 4300 to 6.2 tenthmetres per mm. at λ 6500. The relative displacements of the lines attributed to various elements have been studied, regard being paid to differences between arc and enhanced lines. The character of the spectra seems to indicate a condition for *Procyon* intermediate between *Sirius* and the Sun, whilst *Arcturus* exhibits features generally suggestive of sun-spot conditions.

The spectra of β *Scorpii* and other stars have been studied by Slipher (*Lowell Bull.*, No. 51) with special reference to peculiarities attributable to absorption in space.

A list of peculiar spectra relating to 31 new variable stars is

given by Pickering (*Harv. Coll. Obs. Circ.*, No. 167). This probably completes the list of variables and other objects with peculiar spectra discovered in the Henry Draper Memorial photographs by the late Mrs. W. Fleming, whose too early death is much regretted.

Classification of Stellar Spectra.—At the meeting of the International Union for Solar Research held at Mount Wilson in 1910 it was decided to extend the work of the Union and to include general astrophysics in the scope of its activity. A committee was appointed to deal with the classification of stellar spectra (*Trans. I.U.S.R.*, vol. iii. p. 105). As a first step in the activity of this committee, a number of informal opinions are published in *Ap. J.*, **33**, 260. From them there would appear to be a fairly general feeling in favour of the Harvard alphabetical classification as a system of nomenclature of stellar spectra, and for practical purposes it is already widely used.

It is clear, however, from the readiness with which astrophysicists are willing to condone the displacement of alphabetical succession involved in the rearrangement of the letters in the order O, B, A, F, G, K, M, that there is a desire for something still more systematic, taking account of other criteria than these available when Professor Pickering and his assistants, with wise prevision, adopted the alphabetical nomenclature. The wisdom of not taking precipitate action is well emphasised by the publication of papers like those of Campbell and Boss, which have appeared in the past year, 1911. Even after Campbell's discussion of about 1200 radial motions, and Boss's discussion of close upon 5000 proper motions, each of these investigators demands more stars.

Ever since Pickering's discovery that helium stars, designated in the Harvard nomenclature by the letter B, in general cluster near the Milky Way, a special interest has attached to them. That interest is greatly enhanced by Campbell's recent study of their motions (*L.O.B.*, **6**, No. 195). Frost and Adams called attention in their research of 1904 to the small radial velocities of 20 helium stars, and also to their exceedingly small proper motions. They found that the mean radial velocity was $+4.6$ km/sec, after correcting for the solar motion. Campbell's determination of the elements of the solar motion from the radial velocities of 1047 stars in 1909-10 led him to assume a fixed apex, and to make the velocity of the Sun in space the only unknown, and to solve separately for stars of type I spectrum and for stars of type II spectrum. Incidentally he noticed that the 138 helium stars utilised in these solutions exhibit a peculiarity, namely, that when the measured velocities were freed of the solar motion their algebraic mean was $+4.93$ km/sec. Kapteyn and Frost in 1910 utilised the radial velocities of 61 helium stars to determine the velocity of the solar motion. The stars were grouped chiefly near the apex and antapex of the Sun's way, and it appeared that the apical stars give a solar velocity of 18.38 km/sec, whilst the antapical stars give

28.38. Campbell points out that the difference, 10 km. is about twice +4.93, and he has taken up, with exceedingly interesting results, the further study of 225 class B stars. These stars are mostly (203) brighter than 5.01 magnitude; 77 are north of the equator, 148 are south. They have been used for determination of the elements of the solar motion. Three solutions were made:—

I. Assuming Boss's apex at $270^{\circ}.5$, $+34^{\circ}.3$ derived from proper motions of 5413 stars of all spectral classes, Campbell makes the solar motion an unknown, and assumes that each observed velocity has a systematic error K of unknown origin.

$$V_0 = -19.87 \pm 0.82 \text{ km/sec.}$$

$$K = +3.94 \pm 0.54 \quad ,,$$

He further shows that the introduction of the K term does not affect significantly the resulting value of the Sun's velocity.

II. Assuming Boss's apex again, he finds a solution for 180 stars of classes B to B_5 inclusive, excluding 45 stars of classes B_8 and B_9 .

$$V_0 = -20.69 \pm 0.73$$

$$K = +4.70 \pm 0.47$$

He further shows that the value of K increases for groups of stars according as they are taken from regions increasingly remote from the apex and antapex.

Campbell finds no evidence of preferential directions (two-drift theory) amongst the 180 helium stars he deals with.

III. In a third solution he adopts an apex at 270° , $+30^{\circ}$, approximately midway between the apex he derives from 1200 radial velocities ($268^{\circ}.5$, $+25^{\circ}.1$) and that derived from Boss from proper motions ($270^{\circ}.5$, $+34^{\circ}.3$). This solution gives

$$V_0 = -20.19 \pm 0.81 \text{ km/sec.}$$

$$K = +4.07 \pm 0.53 \quad ,,$$

The cosmical radial velocities (*i.e.* the velocities freed of the solar component) are slightly smaller near the apices, and thus show no sign of preferential motions near the two-drift vertex (93° , $+12^{\circ}$)—a result which seems to raise in an acute form the question what is the true background of reference stars.

One of the most interesting parts of this paper is that relating to the comparison of the τ components of proper motion with the radial motions corrected for the motion of the Sun. The average of the τ components for a number of stars should correspond to the average radial motions cleared of the solar motion components, unless the stars are at appreciably different distances from the observer. Campbell adopts 6 km/sec as the mean residual radial velocity of 180 B- B_5 stars; and comparing this with the value $0''.0076$ for the average annual τ component of these stars, he deduces that their distance is of the order of 540 light-years ($\pi = 0''.0060$). Proceeding similarly with 45 B_8 - B_9 stars, he deduces the distance 240 light-years ($\pi = 0''.0134$). It will be understood

that Professor Campbell gives these figures with all proper reservations. They serve only as indications of distances. If we accept them in this broad sense, Campbell's further discussion of the magnitudes of the B stars is of great interest.

402 B stars	$\left\{ \begin{array}{l} 312 \text{ B} - \text{B}_5 \text{ stars} \\ 90 \text{ B}_8 - \text{B}_9 \text{ stars} \end{array} \right\}$	average visual magnitude 4.3	$\left\{ \begin{array}{l} \pi = 0''.0078 \\ \pi = 0''.0182 \end{array} \right\}$
330 B stars	$\left\{ \begin{array}{l} 208 \text{ B} - \text{B}_5 \text{ stars} \\ 122 \text{ B}_8 - \text{B}_9 \text{ stars} \end{array} \right\}$	“ “ “	5.6 $\left\{ \begin{array}{l} \pi = 0''.0114 \\ \pi = 0''.0095 \end{array} \right\}$

From this it would appear that of B-B₅ stars the fainter group is nearer than the brighter, whereas of B₈-B₉ stars the brighter group is nearer.

Campbell makes several suggestions as to the significance of this K term. It seems likely that a revision of the standard wave-lengths used in reduction of the radial velocities of these B stars will throw light on the matter. An average increase of 0.07 tenth-metre in the wave-lengths of lines utilised would explain the phenomenon. The work of Albrecht (*Ap. J.*, **33**, 130) gives an indication of systematic differences in wave-lengths of lines of definite chemical origin in the different types of stellar spectra; and Merrill's work on P Cygni points to some unconformability of silicon lines. Is a clue to be found in the observed frequency of occurrence of the lines of non-metallic elements (*e.g.*, Si, N, O) in the spectra of the helium stars?

In a second paper (*L.O.B.*, **6**, No. 196) Campbell deals with some peculiarities in the motions of the stars. He had announced in the Silliman Lectures in January 1910 that the velocities of stars are functions of their spectral types. In the paper now referred to, Campbell has used the radial velocities of 1193 objects, making solutions for the solar motion by separate spectral types, and deducing the value of the systematic error K for each stellar class B, A, F, G, K, M. The progressive changes in K are peculiarly interesting. It is zero for the classes F and G (solar type), and increases as we pass to classes A and B in one direction and also to classes K and M in the other direction, as is well shown in the following table extracted from Table III. in the paper.

<i>Assumed Apex 270° 0, + 30° 0.</i>				
Type.	No. of Stars.	V ₀ .	K.	Average Radial Velocity.
B-B ₉	225	-20.2	+4.07	6.47 B-B ₅ (180 stars)
				6.68 B ₈ -B ₉ (45 stars)
A-A ₉	177	-16.8	+0.95	10.95
F	185	-15.8	+0.06	14.37
G	128	-16.0	-0.20	14.97
K	382	-21.2	+2.82	16.8
M	73	-22.6	+3.93	17.14
All	1193	-19.5	+1.91	apex 268° 5, +25° 1
All	1193	-19.5	omitted	„ 268° 5, +25° 3

The evidence afforded by this material for the two-drift theory is fairly favourable. But when one reads that the addition of 159 stars to the 1910 list of 1047 stars halves the cogency of the evidence, it is clear that Professor Campbell is right in desiring a greater mass of homogeneous material. Classes B and A show more strongly a preference for motion in the plane of the Milky Way than do the classes F, G, and K; the M stars hardly exhibit any sign of preference. The discrepancies between the proper motion results and the radial velocity results is well shown by the following details taken from Table VII., relating to magnitude and parallax.

Vis. Mag.	π_m . Type I.		π_m . Type II.	
	Campbell.	Kapteyn.	Campbell.	Kapteyn.
2.51-3.50	0"0076	0"0223	0"0157	0"0515
3.51-4.50	0"0150	0"0157	0"0169	0"0357
4.51-5.50	0"0147	0"0111	0"0119	0"0253

One of the most striking outstanding facts disclosed by Campbell's researches is the difference in the distribution and average velocity of M and B stars.

It seems as if a solution of the perplexities of the present situation might be reached by a judicious combination of (i.) Campbell's view of local origin, (ii.) Eddington's suggestion (*Brit. Assoc.*, 1911) that the larger bright B stars are moving slowly because they are distant from the centre of gravity of their universe, and (iii.) Halm's study of the approach to equipartition of energy (*M.N.*, 71, 610), and (iv.) Russell's indication of the existence of large and small representatives of each stellar class, if only the objections which each of these investigators justly raises against the acceptance of the views of the others could be reconciled.

Campbell, in the two papers above alluded to, inclines to exclude from his discussion of the motions of B stars those individuals that have unusually large velocities. Ludendorff, on the other hand, finds (*Ast. Nach.*, 190, 193) that B stars with large numerical velocities (larger than 7.9 km/sec) arrange themselves strikingly in Lockyer's classification; 10 stars with high positive velocities are arranged on the ascending branch of Lockyer's curve, whilst 8 stars lie on the descending branch, and of these, all except one (π Andromedæ) have negative velocities. This is a feature which is peculiar to Lockyer's classification, and does not appear in the Harvard classification B, B₁ . . . B₉. Ludendorff deals with 18 stars out of the 67 which are common to Campbell's list of 224 B stars, and Lockyer's list, which contains 152 stars in the classes Rigelian, Taurian, Crucian, Alnitamian, Argonian, Achernian, Algolian, Markabian. The following table summarises the facts:—

Lockyer's Genera and number of Stars classified by him.	Rigelian (4).	Taurian (4).	Crucian (59).	Alnitanian (8).	Argonian (2).	Achernian (18).	Algolian (36).	Markabian (21).
Ludendorff } (18)	+9.9 (1)	+21.1 (2)	+12.4 (7)	...	...	-14.6 (4)	-6.3 (4)	...
Common to Campbell and Lockyer (67) }	+3.3 (3)	+8.1 (4)	+3.7 (34)	-0.5 (4)	...	-5.3 (11)	-3.8 (10)	-3.1 (1)
Ditto with Velocities < 8.0 km/sec (49) }	-1.7 (2)	-3.5 (2)	+1.6 (27)	-0.5 (4)	...	0.0 (7)	-2.1 (6)	-3.1 (1)

The distinguishing features of Lockyer's classification are that the spectra of stars on the ascending branch have protometallic lines relatively thick and hydrogen lines thin, whilst those on the descending branch have protometallic lines thin and hydrogen relatively thick.

A similar table may be added summarising the facts relating to Campbell's 224 radial velocities for stars classified according to the Harvard nomenclature.

	B.	B ₁ .	B ₂ .	B ₃ .	B ₄ .	B ₅ .	B ₆ .	B ₇ .	B ₈ .	B ₉ .
Velocities } > 8 km/sec }	-16.4 (1)	-0.2 (6)	-2.1 (4)	+0.8 (19)	+20.3 (1)	+3.8 (17)	...	...	-4.6 (7)	-5.6 (9)
Velocities } All }	-0.5 (14)	+1.8 (16)	-0.4 (27)	+0.7 (68)	+13.2 (2)	+1.1 (53)	...	...	-2.3 (21)	-3.6 (23)
Velocities } < 8 km/sec }	+0.8 (13)	+3.0 (10)	-0.1 (23)	+0.6 (49)	+6.2 (1)	-0.2 (36)	...	...	-1.1 (14)	-2.3 (14)

Lewis Boss, in his third paper on Precession and Solar Motion (*Astron. J.*, 26, p. 187, Nos. 623-624), has made a digression to consider the relation of systematic motions to spectral types. He has selected from the 6188 stars in his Preliminary General Catalogue, 4686 stars as available for this discussion; from them he has deduced the position of the apex and the value of the parallactic motion M as follows:—

Type.	Limits.	No. Stars.	A.	δ.	M.
B	Oe ₅ to B ₅	490	274.4° ± 2.4°	+ 34.9° ± 2.0°	2.73" ± 0.10"
A.	B ₈ to A ₄	1647	270.0° ± 1.3°	28.3° ± 1.1°	4.08 ± 0.08
F	A ₅ to F ₉	656	265.9° ± 2.4°	28.7° ± 2.1°	4.99 ± 0.18
G	G entire	444	259.3° ± 4.7°	42.3° ± 3.5°	3.12 ± 0.19
K	K entire	1227	275.4° ± 2.2°	40.3° ± 1.7°	4.03 ± 0.12
M	M entire	222	273.6° ± 5.2°	38.8° ± 4.8°	3.29 ± 0.23
F, G, K, M	A ₅ to M	2549	270.3° ± 1.5°	37.6° ± 1.2°	3.93 ± 0.08

His results as to parallactic motion M, centennial cross motions τ_0 , ratio $\tau_0 : M$, and value of τ_0 converted into kilometres with

solar velocity V equal to 20 km/sec, are given in the left half of the following table; and for comparison, Campbell's observed mean radial velocities ρ_0 , and centennial value of τ_0 (for the stars actually observed by him) taken from Boss's P. G. C., are given in the right-hand columns:—

Type.	No. Stars.	M.	τ_0 .	τ_0 : M.	τ_0 km.	Campbell 1289 Stars.		
						ρ_0 .	τ_0 .	No. Stars.
B	490	2"73	0"86	0'315	6'3	6'2	0"78	312
A	1647	4'08	2'07	0'508	10'2	9'2	2'48	262
F	656	4'99	4'03	0'81	16'2	14'4	10'75	180
G	444	3'12	2'89	0'93	18'6	15'9	7'47	118
K	1227	4'03	3'04	0'754	15'1	16'8	5'16	346
M	222	3'29	2'82	0'86	17'1	17'1	3'84	71
F, G, K, M	2549	3'93	3'25	0'828	16'6			

Boss's spectral classes differ slightly from Campbell's, and attempt is made in the last table to give a fairer comparison, by taking Campbell's B-B₅ as compared with Boss's B, and by combining Campbell's B₈, B₉ and A to compare with Boss's A. Campbell's F does not include any A stars.

There would appear to be a satisfactory tendency towards agreement between these investigations of Campbell and Boss; and yet Halm's important paper (*M.N.*, **71**, 610) shows that there remains much to be done in reconciling the results of the studies of drifts based on proper motions and on radial velocities. He points to the improvement to be gained in systematisation of results by considering a third drift (O) closely related to the helium stars (class B), and completes a very interesting paper by giving a sketch comparison between observation and calculation to test the view that average speed is inversely proportional to the root of the mass, in accordance with Maxwellian equipartition of energy among the stars. There appears to be a feeling rife that the peculiar motions of the stars are more likely to be due to the attraction of the combined masses than to interchange of energy, which, on account of the infrequency of near approaches, would involve an exceedingly long time for the attainment of anything like a steady state.

Variable Radial Velocity—Notes on variability of velocity are given for the following stars:—

α Cygni	O. J. Lee (Yerkes)	<i>Ap. J.</i> , 34 , 303
„	Neuimin (Pulkova)	<i>Pulk. Mit.</i> , 4 , 38
68 stars noted by Professor Campbell in <i>L.O.B.</i> , 6 , No. 199		
23 „	„ Mr. J. H. Moore	„ „
2 „	„ Mr. W. H. Wright	„ „
1 „	„ Professor Campbell	„ „ (separately noted).

These last-mentioned 94 stars may be summarised as divided among the spectral classes in the following table, wherein the zero suffix indicates the general class without specification of the decimal subdivision:—

O ₀ .	B ₀ .	A ₀ .	F ₀ .	G ₀ .	K ₀ .	M ₀ .
1	25	15	9	9	29	6

The velocity of the centre of gravity of the Algol system is found to be variable in a period of 1·733 years with an amplitude $\frac{1}{2}$ km/sec by Bélyopolsky (*Pulkovo Mitt.*, 4, No. 45); the velocity is zero in 1888·90.

The light-variations of κ Pavonis have been studied by A. W. Roberts (*Ap. J.*, 34, 164). This star is known to have variable radial velocity (Wright, *Ap. J.*, 20, 141).

Light-variations have been detected in α Ursæ Majoris by Hertzsprung (*Ast. Nach.* 189, 89). It is not yet decided whether comparison between spectroscopic data and the light-variations shows it to be of the δ Cephei class.

In the spectrum of α Cygni, Neuimin finds that the velocities deduced from the hydrogen line have smaller values than those from metallic lines (*Pulkovo Mitt.*, 4, No. 38).

Spectroscopic Binary Stars.—Orbits are given for the following binary stars:—

α Persei	Ludendorff	<i>Ast. Nach.</i> , 188, 211
β Lyre (multiple)	R. H. Curtiss	<i>Allegheny Obs.</i> , ii, No. 11
93 Leonis	Cannon	<i>R.A.S. Can.</i> , 1910, p. 452
ϵ Ursæ Majoris	Plaskett	„ „ „ p. 460
ν Orionis	Harper	„ „ 1911, p. 26
7 Camelopardalis (1 sp.)	Harper	„ „ „ p. 112
σ Geminorum (1 sp.)	Harper	„ „ „ p. 200
d Bootis (2 spectra)	Harper	„ „ „ p. 315
b Persei	Cannon	„ „ „ p. 266

Considerations relating (i) to secondary waves in velocity-curves of spectroscopic binaries are given by Zurhellen (*Ast. Nach.*, 187, 433) and (ii) to masses of the spectroscopic binaries by Ludendorff (*Ast. Nach.*, 189, 145).

Stellar Temperatures.—A half-page note is given by Wilsing (*Ap. J.*, 33, 85) in reply to Abbot.

A spectrophotographic determination of the effective temperature of 7 stars has been carried out with a prismatic spectrograph attached to the photographic telescope of the Vienna

Observatory by Hnatek (*Ast. Nach.*, 187, 369) with the following results:—

	Vienna.	Potsdam.	$\frac{r}{r_{\odot}}$
α Aquilæ	...	7100	1.9
α Lyrae	6,810	...	6.1
δ Aquilæ	6,150	6400	...
α Cygni	7,500	...	...
α Cephei	6,480	...	5.1
β Persei	11,600	...	2.1
α Andromedæ	8,490	8000	3.1
η Pegasi	4,000	4200	...

Assuming von Harkányi's ratio of diameters of α Aquilæ and Sun (*Ast. Nach.*, 186, 161), Hnatek deduces the diameters of four of the stars.

Reduction Methods and New Instruments.—A method of utilising numerous standard lines in the reduction of stellar spectra by means of the Hartmann-Cornu formula is given by Stratton (*M.N.*, 71, 663).

A description of the single-prism spectrograph of the Ottawa Observatory is given by Plaskett in the 1909 report of the Ottawa Observatory (published in 1911), together with much information about radial velocities determined in the previous year.

A new observatory to be devoted to astrophysical work at Tübingen is announced by Rosenberg (*Ast. Nach.*, 189, 365).

An arrangement for giving approximately monochromatic images of light-sources is described by Pokrowsky (*Ast. Nach.*, 189, 369) under the name spectrohelioscope.

H. F. N.

Selenium Photometry.

During the past few years Professor Stebbins has been investigating the application of the Selenium Cell to Astronomical Photometry, and his recent work shows that the method is capable of a high degree of accuracy.

The first noteworthy application of the method was in 1907, when Stebbins and Brown (*Ap. J.*, xxvi. 326) measured the variation in the total radiation of the Moon at various phases. They observed the galvanometer deflection produced by the current passing through the cell when illuminated by the Moon, and again when illuminated by a standard candle at various distances, and by interpolation found at what distance the candle would give the same deflection as the Moon. The intensity of the Moon's radiation

was thus expressed in terms of the intensity of the candle at a known distance, without making any assumption as to the relation between the galvanometer deflection and the intensity of the light. Different cells gave consistent curves for the variation of intensity with phase, but the actual candle-power of the full Moon given by the different cells varied between limits in the ratio of 7 to 37.

In a later paper (*Ap. J.*, xxvii. 183) Stebbins showed by a comparison of the sensibility curves of the separate cells to sunlight that the curves connecting sensitiveness and wave-length varied considerably for the four cells used, so that though the cells are capable of giving relative measurements of the intensity of light with great accuracy, the absolute measurements vary with the treatment the selenium has received in the preparation of the cell. The cells are in fact analogous to photographic plates in this respect, but with the advantage that a single cell can be used repeatedly, whilst a photographic plate can be used only once. The cells differ from the eye and the photographic plate in being more sensitive to the visible red rays.

The method of preparation of commercial selenium cells is a trade secret, but the makers themselves are very much in the dark as to the conditions necessary to secure uniform sensitiveness.

Stebbins has shown that his method is specially suited to the investigation of the light variation of variable stars. His principal paper is that on Algol (*Ap. J.*, xxxii. 185), where he states the conditions he has found necessary for accurate measurements. He finds that Algol has a secondary minimum, with a dip of .06 mag. and a continuous variation of intensity between the principal and secondary minima. He concludes that the companion star is not dark, but emits more light than our Sun, that it always turns the same face towards the primary, and that this face is much brighter than the face that is turned away from the primary.

Investigation of the spectroscopic binary β Aurigæ (*Ap. J.*, xxxiv. 112) led Stebbins to the discovery that it is an eclipsing variable with a range of .087 mag. The importance of this discovery lies in the fact that the spectra of both components are visible, and the parallax of the system has been measured, so that it is possible to find the surface intensity per unit of area. He calculates that each component emits per unit area almost certainly more than 12 times, and possibly 25 times, as much light as the Sun, thus confirming the view that Sirian stars are intrinsically brighter than solar stars.

Stebbins has also applied his method to measuring the light variation of Halley's Comet (*Ap. J.*, xxxii. 179); and he reported to the Ottawa meeting of the Astronomical and Astrophysical Society of America that he had made observations of the light curves of α Orionis and δ Orionis, the latter of which he found to be an eclipsing variable.

J. W. C.

Astrographic Chart and Catalogue.

The publications during the year 1911 comprise tome iii. of the Paris Catalogue (*co-ordonnées rectilignes* zone $+21^{\circ}$ à $+23^{\circ}$), which is the first of the series published by M. Baillaud with the help of M. Lagarde, who is now chief of the computing department in place of the late M. Bossert. This volume contains the measures of the 180 plates whose centres are at declination 22° N., the two previously issued volumes having contained similar measures of the plates of declination 24° N. and 23° N. There therefore remain to be published from this Observatory the measures of plates of the four zones 18° N. to 21° N.

There has also been published volume vii. of the Oxford series containing the rectangular coordinates of the stars on the plates of zone 25° N., which completes the publication of the measures of the Oxford Zone. (The completion of this zone was reported last year in this place by error.) This Observatory has also distributed an additional volume of tables for the conversion of R.A. and Dec. into standard coordinates and *vice versa*, applicable to the plates of the Oxford Catalogue, collected from the seven separate volumes. The first instalment of the catalogue from Perth Observatory (West Australia) has appeared in 1911. The plates assigned to this Observatory are those which have centres at declinations 32° S. to 40° S. inclusive, and it is proposed to publish the measures of these in sections, each comprising 6^h of R.A. for one degree of declination—36 in all. The section now issued, numbered volume iv., contains rectangular coordinates and magnitudes of 13636 star images in R.A. 18^h to 24^h , or plates with centres in declination 32° S. The measures of coordinates were made with a scale in the eyepiece of the micrometer as at Greenwich and Oxford, and are given in *réseau* intervals to three places of decimals. The magnitudes, determined partly by measures of diameter and partly by comparison with an empirical photographic scale, are given in units of .3 of a magnitude. There is reason for thinking that the publication of the measures made at the Cape of Good Hope Observatory will be begun shortly.

From a report of the Algiers Observatory for 1910 it appears that the replacing of the catalogue plates (it has been already reported that many of those originally taken were found to be defective) is proceeding, as well as the taking of the chart plates. The plates assigned to this Observatory are those with centres in declination 4° N. to 2° S. inclusive. The zones 3° and 4° N. are completed, and it is estimated that the retaking of the four northern zones will be finished in two years. The publication of the zones 0° and 2° S. is proceeding.

From a report from the Toulouse Observatory for 1910 it appears that the publication of the catalogue will be soon begun.

It will be seen from a paragraph on another page of this

Report that at Greenwich a catalogue of stars within 3° of the North Pole is being compiled from the measures in volume ii. already published, and that photographic magnitudes are being deduced from the measured diameters in volumes i. and ii. of the *Astrographic Catalogue*. These will form part of the catalogue of Right Ascensions and Declinations of stars deduced from measures of photographs, to be published shortly.

Mention may be made of a meridian catalogue made at the Royal Observatory at Uccle (Brussels) of 3553 stars of declination between 21° N. and 23° N., to be used as reference stars for the *Astrographic Catalogue*.

The following table shows the total number of enlarged reproductions of chart plates distributed by the different observatories up to the end of the year 1911. It may be specially remarked that the zone 9° S. has been completed by the San Fernando Observatory.

Algiers . . .	385	San Fernando . .	326
Bordeaux . . .	184	Tacubaya . . .	228
Brussels . . .	9	Toulouse . . .	245
Paris	416		

H. P. H.

Precession Tables.

Under the title "Tablas para reducir Posiciones estelares al Equinoccio Normal 1925," Dr. F. W. Ristenpart has issued from the Observatory of Santiago de Chile a new set of precession tables. They are constructed on an original plan. Dr. Ristenpart has been greatly impressed by the immense labour which is required in bringing different meridian catalogues to a common equinox for the purpose of mutual comparison. The common practice has been to make the equinox of a catalogue correspond approximately with the mean epoch of the observations. A great economy of labour would be effected by the general adoption of a normal equinox for all catalogues formed within a given, fairly extended period. In the present case it is proposed that all catalogues formed in the first half of the twentieth century shall be referred to the normal equinox 1925, and the present tables give the means of calculating the precessions between the equinoxes from 1900 to 1924 and this normal equinox.

As the proposal is an important one, the relation of the new tables to the usual method may be briefly indicated. According to present practice, if T is the equinox of the catalogue, we calculate the place of a star for another equinox t by the formulæ

$$\begin{aligned} \alpha_t &= \alpha_T + B_1(t-T) + B_2(t-T)^2/200 + B_3(t-T)^3/10^6 \\ \delta_t &= \delta_T + C_1(t-T) + C_2(t-T)^2/200 + C_3(t-T)^3/10^6 \end{aligned}$$

where the coefficients, which are functions of α and δ , are given in the catalogue for each star and are themselves derived from

special tables. In Dr. Ristenpart's tables, on the other hand, t as well as T is fixed, and the calculation is made by the formulæ

$$\begin{aligned} a_t &= a_T + A + A_1 \tan \delta_T + A_2 \tan^2 \delta_T \\ \delta_t &= \delta_T + D + D_1 \tan \delta_T \end{aligned}$$

where t is 1925 throughout. The five coefficients are functions of a_T , and are all conveniently tabulated with this argument on two opposite pages for each year T from 1900 to 1924 and 1875. The work is based on Newcomb's constants. It appears that the convergence in these expansions according to $\tan \delta$ is more satisfactory than that according to $t - T$. The reverse process of calculating precessions from 1925 can be effected by the present tables, but a further set of tables more suitable for the purpose is promised. At the end are given tables for the calculation of differential aberration, precession, and nutation.

Dr. Ristenpart's plan will commend itself to many astronomers, both in respect of its general conception and its execution. But it is possible that one important point will not be so readily conceded by those who may be ready to adopt the fundamental principle. This refers to the particular choice of 1925 as the normal equinox. The Astrographic Catalogues will contain the material for an immense number of star places referred to the equinox 1900. This in itself constitutes a claim for 1900 to be considered as a normal equinox, while 1925 is a purely arbitrary date. And it would have the advantage that it could be carried on indefinitely, with little breach of continuity in the work of the present day, until such time as the plan was found by actual experience to entail practical inconveniences outweighing its manifest advantages.

H. C. P.

Logarithmic Tables.

After a number of years in which no general logarithmic tables have appeared which possess any distinctive features worthy of remark, several works of this kind have been published which are deserving of note. These comprise:—

1. Logarithmisch-trigonometrische Tafeln mit acht Dezimalstellen, neu berechnet und herausgegeben von Dr. J. Bauschinger und Dr. J. Peters. Leipzig: W. Engelmann, 1910, 1911.
2. Siebenstellige Logarithmentafel, bearbeitet von Professor Dr. J. Peters. Leipzig: W. Engelmann, 1911.
3. Nouvelles Tables Trigonométriques Fondamentales, par H. Andoyer. Paris: A. Hermann et fils, 1911.

(1) The need for 8-figure logarithms was first felt in astronomical practice owing to the need for accurate ephemerides of the minor planets employed for the determination of the solar parallax. The only existing work of this order available was the "Table de logarithmes de service géographique de l'armée"

(Paris, 1891), and this was rendered inconvenient in the trigonometrical section by the adoption of the centesimal division of the arc. The new German tables have been prepared with the assistance of subsidies made by the Berlin and Vienna Academies, and are published in two volumes. The first contains the logarithms of the numbers 100,000 to 200,000 and 20,000 to 100,000, arranged in the usual modern form and provided with proportional parts for every difference which occurs, except in a few pages following 20,000, where space allows only alternate differences to be given. The second volume contains the logarithms of the circular functions for every sexagesimal second of arc, the four functions being placed together in consecutive columns under each minute of arc. In addition the functions S and T ($\log \sin x/x''$ and $\log \tan x/x''$) are given for the first five degrees. It has not been found practicable to provide proportional parts in this volume.

The construction of the tables is based on the original 14-figure tables of Briggs, *Arithmetica logarithmica* (1624) and *Trigonometria Britannica* (1633). These were subjected to tests which detected a few errors and assured their accuracy. They were then reduced to 12 figures and extended by interpolation to the required interval. The interpolation was carried out with the help of a calculating machine, specially constructed by Herr Hamann of Friedenau (Berlin), which included second differences in the calculation and printed the results. The authors of the tables express complete satisfaction with the performance of the machine.

(2) Three tables of 7-figure logarithms of the trigonometrical functions for every second of arc exist, those of Taylor, Bagay, and Shortrede. The tables of Bagay have been reprinted recently, while the others are out of print and scarce. All of these tables are more or less inconvenient in form, and those of Bagay have been found to be extremely inaccurate. Dr. Peters is therefore well justified in printing a new 7-figure table of the logarithmic functions for every second of arc based on the 12-figure table, the construction of which has been alluded to above. The form of the tables is similar to that of the corresponding section of the 8-figure tables, the only differences being that the functions S and T are given only for the first two degrees; and proportional parts, which become complete after $3''$, are provided.

(3) The number of essentially original tables of trigonometrical logarithms is three, namely, the *Trigonometria Britannica* (14-figure) of Briggs (1633) mentioned above, the *Trigonometria artificialis* (10-figure) of Vlacq (1633), and the French *Tables du Cadastre* (1794-9), of which the last are based on the centesimal division of the arc and have never been printed. M. Andoyer has therefore carried out an entirely new calculation, and his work has been published with the help of a subsidy granted by the University of Paris. He has provided original 14-figure tables of the trigonometrical functions, the interval of the argument

being 10". The first difference, correct to the last figure, is also given. In addition the 17-figure table for every 54' and the 15-figure table for every 9', on which the work is based, are printed, together with a 14-figure table of S and T for every 10" of the first three degrees. The whole calculation was completed in a period of twenty months, without any assistance personal or mechanical, in the leisure allowed by other occupations.

H. C. P.

The Paris Conference on Nautical Almanacs.

On the initiative of the Bureau des Longitudes a very successful conference between the Directors of National Ephemerides and some of the leading practical astronomers of the world was held in Paris, October 23-26. At the first meeting the chair was taken by M. Baillaud, who had on his right M. Bayer, representing M. Steeg, Ministre d'Instruction publique, and Sir David Gill was nominated Président d'honneur, Dr. Backlund, Vice-président, with M. H. Andoyer and the Comte de la Baume Pluvinel as Secretaries. There were present besides, Prince Roland Bonaparte (Member of the Academy of Sciences); the following Directors of ephemerides, Dr. Cowell (London), Fritz Cohn (Berlin), Eichelberger (Washington), Général de Azcarate (San Fernando), Boccardi (Turin); as Directors of Observatories, Dr. Dyson (Greenwich), Hough (Cape), Perrine (Cordoba), André (Lyons), Picart (Bordeaux), Verschaffel (d'Abbadia); from the Bureau des Longitudes, MM. Bigourdan (President), Poincaré, Radau, Deslandres, and Hanusse. An address was given by M. Baillaud, and a cordial speech of welcome by M. Bayer. Further meetings were held on October 24 and 25, when a unanimous agreement on all points was reached. On October 26 the directors of the ephemerides met to make final co-operative arrangements, and their report was adopted by the congress on the afternoon of the same day.

The main purpose of the meeting was to obtain, if possible, a greatly increased list of star ephemerides; if the recommendations are carried out, more than 3000 of these will be printed in one or other of the almanacs, places being given for every ten days, except in the case of those within 10° of either pole, for which daily places will be published. Places of the Sun, Moon, and planets will be computed from two sets of tables, and all will be referred to the Greenwich meridian; this will greatly facilitate comparison. Berlin undertakes to give five places at ten-day intervals near opposition for every minor planet for which sufficient data exist, and to compute the orbit of any planet of which six weeks' observations have been obtained. These minor planet ephemerides will be calculated from elliptic elements, and will not include perturbations, but the elements will be altered

from time to time, so that the position of the planet will be known very approximately.

The proceedings of the Conference were characterised throughout by the most complete harmony and goodwill, whilst nothing could exceed the kindness and hospitality, both public and private, with which the members were received.

The following is a translation of the provisional resolutions adopted, these being subject to the approval of the Governments concerned.

The Conference strongly recommends that—

1. In all ephemerides the ecliptic coordinates of the Sun should be given for Greenwich mean noon, and that the equatorial rectangular coordinates should be given for midday and midnight of Greenwich mean time.

2. The ecliptic coordinates of the Moon should be given at least for 0^h and 12^h of Greenwich mean time.

3. The ecliptic heliocentric and geocentric coordinates of the planets should be given for 0^h or 12^h of Greenwich mean time.

4. The ephemerides of the stars, that is to say, their corrections from mean to apparent place, should be calculated for upper transit at the meridian of Greenwich.

The Conference is of opinion that the adoption of the meridian of Greenwich for all ephemerides should be realised as soon as possible.

The Conference is of opinion that in all catalogues and collections of observations, Declinations instead of Polar distances should be adopted.

The Conference decides that those portions of the ephemerides which deal with the data necessary for the calculation of the perturbations of the small planets and comets shall be based on the masses of the planets adopted by Newcomb.

The Conference decides that the names of stars shall be accompanied by a letter indicating their spectral type in terms of Pickering's notation. It is of opinion that these indications, so far as they have been determined, should in future be given in the list of 3064 stars to be published by the "Bureau des Longitudes."

The Conference decides that in future the stars in the fundamental and standard lists of Auwers, Boss, and Newcomb shall be designated by the letters A, B, N, and the Backlund-Hough stars by the letters B.H.

For the prediction of occultations of stars the list of the Nautical Almanac shall be adopted.

The Commission adopts the following resolutions:—

For the sake of uniformity in the calculation of parallaxes, eclipses and occultations, the ephemerides shall adopt for the value of the compression of the Earth the number $1/297.0$ resulting from the final researches of Messrs. Tittmann, Hayford, and Helmert.

For like reasons in the calculation of eclipses the semidiameter of the Sun, $15' 59'' \cdot 63$ (Auwers) shall be retained, as already employed in all ephemerides.

The bureaux charged with the calculation of eclipses of the Sun and Moon and the occultations of stars shall choose in common agreement the tables and apparent diameters which they find most desirable, taking care to communicate in the most precise and complete fashion the data which they employ, and the origin whence the adopted data have been derived.

The Conference decides that the *Connaissance des Temps* shall continue to calculate the positions of the Sun and of the planets from the Le Verrier-Gaillot tables; the Bureau des Longitudes will in future compute the positions of the Moon from the new tables of M. Radau, which are based upon Delaunay's theory. In the other ephemerides these calculations shall be based on the tables of Newcomb and of Hill for the Sun and planets, and on Hansen's Tables, with Newcomb's corrections, for the Moon, until such time as the latter tables shall be replaced by the new tables of Brown.

This second series of solar, planetary, and lunar calculations shall be undertaken by the Nautical Almanac Office, with the exception of the ephemeris of Mercury, for which the office of the *Berliner Jahrbuch* shall be responsible.

Relative to the Stars.

1. The corrections from mean to apparent place of the stars B.H. shall be computed at the Nautical Almanac Office, and be printed by the Observatory of Pulkowa; the same will apply to the daily corrections of the principal fundamental clock-stars, which latter shall include the lunar terms of short period.

2. The ephemerides of such of the stars A, B, N as do not occur in the list of Auwers stars which is published annually in the *Berliner Jahrbuch* shall be calculated and printed in the Observatory at Turin.

3. The ephemerides of the Auwers stars shall be calculated and printed by the *Berliner Jahrbuch*, with the exception of the 343 stars printed within brackets; the calculation of the ephemerides of these latter shall be undertaken by the *Almanáque Náutico*.

4. The ephemerides of the Polar Stars, that is to say, of all the stars situated within 10 degrees of North or South Polar distance which are to be found in the provisional list of 3064 stars published by the Bureau des Longitudes, and of the other Polar stars hitherto given in the ephemerides, shall be calculated from day to day by the *Almanáque Náutico*, and shall contain the terms of short period, whose values shall be separately indicated; however, for Polar Stars situated between 80° and 83° declination, it will be sufficient to give the ephemerides for each alternate day.

The *Connaissance des Temps* undertakes to print all the

ephemerides of the above-mentioned stars which are not given in other similar works.

The ordinary ephemerides of the stars shall be calculated to $0^{\circ}001''$ in R.A. as far as 60° of Dec. and to $0''\cdot01$ in Declination, not for each tenth day, but for each tenth successive culmination at the meridian of Greenwich, in order to facilitate interpolation; they will be accompanied with the data necessary for the computation of the terms of short period.

The calculation of the constants of reduction shall be carried out at each bureau in the usual way with 4 or 5 decimals.

Relative to Eclipses and Occultations.

The calculation of eclipses of the Sun and Moon shall be made (in conformity with the rules established by the preceding resolutions); once by the American ephemeris and once by the *Connaissance des Temps*.

The computation of occultations shall be made in duplicate by the American ephemeris.

The predictions of eclipses and occultations shall be made with all possible precision.

Relative to Satellites.

1. The calculation of new ephemerides of the four principal satellites of Jupiter and their phenomena shall be made by the Bureau des Longitudes, and be based on Sampson's new tables.

2. The ephemerides relative to the ring and to the satellites of Saturn (with the exception of Phœbe) shall be calculated by the *Berliner Jahrbuch*.

3. The calculations of the ephemerides of the Satellites of Mars, of the new satellites of Jupiter, of Phœbe, and of the satellites of Uranus and Neptune, shall be made by the American Ephemeris.

The ephemerides relative to the physical observations of the Sun, Moon, planets, etc., shall be calculated by the American Ephemeris, except the ephemerides of the Crater Mösting A, which will continue to be published by the *Berliner Jahrbuch*.

The computation and printing of the ephemerides of the small planets and variable stars shall be undertaken by the *Berliner Jahrbuch*.

It is desirable that the calculations made by any one of the bureaux should be communicated to other bureaux which have to use them at least three years in advance.

The above conventions will be put in force in such a way as to be complete in 1917.

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Amsterdam, Koninklijke Akademie van Wetenschappen.

Antwerp, Société d'Astronomie.

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Barcelona, Sociedad Astronomica.

Basel, Naturforschende Gesellschaft.

Basel, Universität.

Batavia, Royal Magnetical and Meteorological Observatory.

Batavia, Koninklijke Natuurkundige Vereeniging.

Berlin, Deutsche Physikalische Gesellschaft.

Berlin, Königlich Astronomisches Recheninstitut.

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Berlin, Königliche Sternwarte.

Bern, Sternwarte.

Bern, Universität.

Besançon, Observatoire National Astronomique.

Bologna, Osservatorio della R. Università.

Bologna, Reale Accademia delle Scienze.

Bombay Asiatic Society.

Bombay, Government Observatory.

Bordeaux, Observatoire.

Bordeaux, Société des Sciences Physiques et Naturelles.

Boston, American Academy of Arts and Sciences.

Brazil, Sociedade Scientifica de São Paulo.

Brussels, Académie Royale des Sciences de Belgique.

Brussels, Société Belge d'Astronomie.

Budapest, Königl. Ung. Reichsanstalt für Meteorologie und Erdmagnetismus.

Budapest, Magyar Tudományos Akadémia.

Cape of Good Hope, Royal Observatory.

Cape Town, Royal Society of South Africa.

Cape Town, South African Association for the Advancement of Science.

Catania, Reale Osservatorio.

Catania, Società degli Spettroscopisti Italiani.

Cherbourg, Société Nationale des Sciences.

Cincinnati Observatory.

Copenhagen, Kongelige Danske Videnskabernes Selskab.

Copenhagen, Observatorium.

Cordoba, Observatorio Nacional Argentino.

Cordoba, Oficina Meteorológica Argentina.

Cracow, Académie des Sciences.

Dijon, Académie des Sciences.

Dorpat (Jurjew), Kaiserliche Universitäts-Sternwarte.

Egypt, Survey Department.

Geneva, Observatoire.

Geneva, Société de Physique et d'Histoire Naturelle.

Göttingen, Königliche Gesellschaft der Wissenschaften.

Granada, Observatorio Astronomico, Geodinamico y Meteorologico.

- Halle, Kaiserlich Leopoldinisch-Karolinische Akademie.
Hamburger Sternwarte in Bergedorf.
Harvard College Astronomical Observatory.
Heidelberg, Astrophysikalisches Observatorium.
Helsingfors, Fiska Vetenskaps Societet.
Helsingfors, Institut Météorologique Central.
Helwân, Khedivial Observatory.
Hobart, Royal Society of Tasmania.
India, Astronomical Society.
India, Survey Department.
Japan, Astronomical Society.
Johannesburg, Transvaal Observatory.
Kalocsa, Haynald—Observatorium.
Kasan, Observatoire de l'Université Impériale.
Ksara [Syria], Observatoire.
Kodaikânal Observatory.
Königsberg, Königlich Universitäts Sternwarte.
Leipzig, Astronomische Gesellschaft.
Leipzig, Fürstlich Jablonowski'sche Gesellschaft.
Leipzig, Königlich Sächsische Gesellschaft der Wissenschaften.
Lick Observatory.
Lisbon, Sociedade de Geographia.
Lowell Observatory.
Lund, Astronomiska Observatorium.
Madrid, Observatorio Astronomico.
Madrid, Real Academia de Ciencias.
Manila, Philippine Weather Bureau.
Mauritius, Royal Alfred Observatory.
Melbourne Observatory.
Meudon, Observatoire Physique de Paris.
Milan, Reale Osservatorio di Brera.
Moncalieri, Osservatorio Centrale del R. Collegio Carlo Alberto.
Montpellier, Académie des Sciences et Lettres.
Moscow, Observatoire Astronomique.
Moscow, Société Impériale de Naturalistes.
Mount Wilson, Solar Observatory.
Münich, Königlich Bayerische Akademie der Wissenschaften.
Münich, Königliche Sternwarte.
Naples, Osservatorio.
Naples, Reale Accademia delle Scienze.
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Oporto, Academia Polytechnica.
Ottawa, Dominion Astronomical Observatory.
Paris, Académie des Sciences.
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- Paris, Observatoire.
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 Queensland, Royal Geographical Society.
 Rio de Janeiro, Observatorio.
 Rome, Reale Accademia dei Lincei.
 Rome, Reale Osservatorio del Collegio Romano.
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 San Francisco, Astronomical Society of the Pacific.
 Santiago de Chile, Observatorio Astronomico.
 St. Louis, Laws Observatory of the University of Missouri.
 St. Petersburg, Académie Impériale des Sciences.
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 Stockholm, Kongliga Svenska Vetenskaps-Akademie.
 Stockholm, Observatorium.
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 Sydney, Royal Society of New South Wales.
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 Tokyō, Observatoire Astronomique.
 Toronto, Canadian Institute.
 Toronto, Royal Astronomical Society of Canada.
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 Turin, Reale Accademia delle Scienze.
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 Upsala, Kongliga Vetenskaps-Societet.
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ADDRESS

Delivered by the President, F. W. Dyson, M.A., LL.D., F.R.S., on presenting the Gold Medal of the Society to Mr. A. R. Hinks.

THE Gold Medal of the Society has been awarded by the Council to Mr. Arthur Robert Hinks for his Determination of the Solar Parallax from Observations of Eros. It is my privilege to lay before you the grounds of this award.

In the times of the Ptolemaic system the Solar Parallax was considered to be about $3'$. This number, though largely in error, sufficed to express the conviction that the Sun was much more distant than the Moon, but nearer than the fixed stars.

After the nature of the planets had been discovered by Galileo's telescope and the Copernican system firmly established, the Solar Parallax acquired a new importance. In 1672, forty years after the publication of the *Dialogue on the Two Chief Systems of the World*, and fifteen years before the publication of the *Principia*, Cassini obtained $9''.5$ as its value from observations of Mars made simultaneously at Paris and Cayenne. This value, corresponding to a distance of 87 million miles, gave a just idea of the scale of the solar system and the sizes of the Sun and planets.

It was pointed out by Halley that a much more accurate determination might be obtained by suitable observations at a Transit of Venus. The opportunities afforded in 1761 and 1769 were fully utilised, but the hoped-for accuracy was not attained. Nevertheless the value of the parallax $8''.57$, deduced by Encke in 1822 from a discussion of these observations, was generally adopted till about 1850.

By this time the Solar Parallax, as an Astronomical Constant, had lost its isolated and independent position. The movements of the Sun, Moon, and planets had been calculated with a high degree of precision, as consequences of the law of Universal Gravitation. It was shown that the algebraical formulæ which represent their movements contain terms into whose coefficients the Solar Parallax enters as a factor. Moreover, Sun, Moon, and planets had by this time been accurately observed for so long a period that these coefficients admitted of accurate determination by comparison with observation. Thus Hansen in 1854 found from the parallactic inequality in the lunar theory a value of $8''.92$ for the Solar Parallax. In 1858 Leverrier obtained the value $8''.95$ from the lunar equation in the motion of the Sun, and a few years later showed that this larger value was required by the theories of Venus and Mars.

If the Solar Parallax were an isolated constant, though the most important in astronomy as giving the scale of the solar system

and the base line from which the stellar universe is surveyed, astronomers might be satisfied if its value were known with a moderate degree of precision. But when it is found that the theories of the Moon or planets give a value of the parallax differing from that found by a direct method, it becomes of importance to determine which is right, and to elucidate the causes of difference. The transits of Venus of 1874 and 1882 were therefore observed with the greatest care and completeness, but with disappointing results. Greater success attended the Heliometer Observations of Mars at opposition made in the Island of Ascension in 1877 by Sir David Gill, who obtained the value of $8''.78$ with a p.e. of $\pm''.012$ for the Solar Parallax. It is just thirty years since he was awarded the Gold Medal of the Society for this work.

As you know, Sir David Gill did not stop here, but by a very extensive series of observations of the planets Victoria, Iris, and Sappho at the favourable oppositions of 1888 and 1889 obtained the value of $8''.802$ with the small p.e. of $\pm''.005$.

In the meantime the velocity of light had been determined with great accuracy by Newcomb and Michelson. This has the effect of bringing three other classes of astronomical observations into direct relationship with the Solar Parallax: viz., the light equation of Jupiter's Satellites, the Constant of Aberration, and determinations of the radial velocities of stars as seen from opposite positions of the Earth in its orbit. At the time when the observations were made on which our Medallist's work is based, the aberration of light was the only one of these methods which gave results of sufficient accuracy to bear comparison with the trigonometrical determinations. Great weight was attached to the aberrational method by some astronomers, notably by Professor Newcomb, and a considerable weight to the gravitational determination from the motion of the Node of Venus. Objections were urged against the gravitational method on the ground that there are in the Solar system several small unexplained differences between theory and observation. We are therefore not certain that the movement of the Node of Venus may not be partly due to some cause unknown at present. Against the determination of the Solar Parallax *via* the Aberration Constant it was urged that the validity of the law connecting the aberration with the velocity of the Earth and the velocity of light has not been theoretically established. Against the heliometer determinations from a minor planet, it was urged by Professor Newcomb that an error might be introduced by differences in the amount of the refraction, if the planet were not of the same colour as the comparison stars.

I will now give a short account of our Medallist's work before he was attracted by this great problem. Mr. Hinks was distinguished at college for his knowledge of practical astronomy, and in the year 1895 was appointed by Sir Robert Ball assistant at Cambridge Observatory. This observatory had undertaken a zone of the great catalogue of the Astronomische Gesellschaft. This arduous and important piece of work was nearing completion when Mr. Hinks

joined the staff of the observatory; he assisted in its final stages, and thus acquired valuable experience of the accuracy of meridian observations and the sources of error to which they are liable. On the completion of the catalogue the Cambridge Observatory turned its attention to work of another kind. In the year 1898 a photographic equatorial of novel design was added to its equipment with the special intention of research on stellar parallax. In an account of the telescope and its installation communicated to the Society in January 1899, Sir Robert Ball makes special reference to the incessant attention given by Mr. Hinks to the carrying out of the details of the building and the erection of the instrument. It is not necessary for me to say more than that Mr. Hinks made the fullest use of the opportunity which the erection and adjustment of this new instrument gave him. It enabled him to acquire in the best way that thorough knowledge of the conditions for accurate photographic astronomy which he turned to such good use later.

Many astronomers are indebted to him for an investigation he made on the best width of lines for *réseaux*. Messrs. Gautier used to rule lines $0^{\text{mm}}\cdot 01$ wide on their silver-on-glass *réseaux*. But the photographic copies made from them have very wide lines, unless the photographic plate is placed close to the glass *réseau*; and this cannot always be done, because plates are not absolutely plane. Mr. Hinks' experiments showed that, with a separation of only $0^{\text{mm}}\cdot 05$ from the *réseau*, the photographed lines were fuzzy and the first pair of diffraction bands were conspicuous. As the distance between the diffraction bands varies inversely as the width of the line, Mr. Hinks was led to experiment with broader lines. He found that a width of $0^{\text{mm}}\cdot 02$ gave the best result, and that the improvement due to these wider lines was so great that the distance between the plate and the *réseau* might be increased to $0^{\text{mm}}\cdot 5$ without the definition of the image being seriously impaired. At the same time he pointed out the advantage of printing the *réseau* by means of a small source of light placed at a distance from the plate equal to the focal length of the telescope.

His attention was next directed to the construction of a measuring machine for stellar photographs. He decided to use a *réseau* as in the Carte du Ciel photographs, and to measure the distance of a star from the sides of the enclosing *réseau* square by means of a glass scale in the eyepiece of the microscope, as in the Oxford and Greenwich astrophotographic micrometers. But he made the divided glass scale movable by a micrometer screw, and thus obtained the accuracy necessary for refined observations such as those of parallax. The chief part of any distance to be measured is read off on the scale, but the fractional part of the scale is not estimated, but measured by the screw. His ideas were embodied by Mr. Horace Darwin in a beautiful machine with which stellar photographs are easily measured with all the accuracy of which they are capable—the limit being imposed not by the measurement, but by the irregularities of the images themselves. Judged by some standards, these irregularities in good photographs are not

large. Mr. Hinks found them to give rise to errors of about $0''.07$, but the error of a single setting of his measuring machine was not more than $0''.02$. The same principles were adopted later in a measuring machine at Greenwich, with the same satisfactory results.

These researches of our Medallist are all directed to one end—viz., to obtain the highest precision from stellar photographs. The instrument must be adjusted and handled so that the images of the stars are the best that can be obtained; and the photographs measured up to the limit of accuracy imposed by the images. These preparations for the important and delicate work of determining the distance of stars were equally necessary for the still more difficult task of determining the Sun's distance. The discovery of Eros by Dr. Witt in August 1898 gave astronomers a most favourable opportunity for again attacking the problem. For this planet at the opposition immediately following discovery, *i.e.*, in November 1900, would, it was calculated, approach within 30 million miles of the Earth and appear as a star of 9.0 m., and with no perceptible disc. Astronomers recognised that the chance thus afforded of a determination of the Solar Parallax ought to be utilised to the fullest extent.

The observatories which were co-operating in the international chart and catalogue were in possession of suitable instruments. By a research on the Solar Parallax a thorough knowledge of the capacities of photographic telescopes for work of the highest precision would also be obtained. At the meeting of the Astrophysical Chart Conference in Paris in July 1900 it was resolved to organise such a research. In one way or another no less than fifty-eight observatories took part, some making photographic and others micrometric observations of the planet, while many others co-operated in making meridian observations of reference stars. We owe to M. Loewy a great debt for the leading part he took in the organisation of this work. He chose the reference stars and undertook the preparation of Ephemerides of the planet. He carried out the laborious task of collecting the diverse observations of the many contributors, and published them in a series of circulars, extending altogether over many hundred pages. M. Loewy did not live to see the completion of Mr. Hinks' researches, but he saw enough to be assured that the memorable enterprise to which so much care and labour had been devoted would lead to a value of the Solar Parallax of much greater precision than any previously obtained.

In his capacity as Chief Assistant of the Cambridge Observatory, Mr. Hinks was responsible for the photographic observations of Eros during the winter 1900–1901. He set himself the task of making four exposures on the planet every hour between 6 p.m. and 6 a.m. throughout the opposition, and carried out this arduous programme as far as weather permitted. I need only say of these observations that they are sufficient of themselves to give the Solar Parallax correct to one part in a thousand.

In November 1901 Mr. Hinks published in the *Monthly Notices* an experimental reduction of the photographs of Eros taken at Cambridge on two consecutive nights. This led him to draw attention to the necessity for computing the Ephemeris of Eros with eight- instead of seven-figure logarithms. In June 1902 he made a further experiment by combining with his own photographs on these two nights others taken nearly simultaneously at Lick, Minneapolis, and Northfield, thus eliminating errors of the ephemeris. The results of these trials encouraged him to make a further experiment on a larger scale, and in June 1904 he published a determination of the Solar Parallax from measures made on plates taken between November 7 and November 15 at the observatories of Algiers, Cambridge, Lick, Minneapolis, Northfield, Oxford, Paris, San Fernando, and Tacubaya. He was led to the following important conclusions:—

(1) That some of the series of photographs were affected by large systematic errors.

(2) That it was necessary to form a system of stars nearer to the planet and more nearly of its magnitude than the reference stars which had been observed by meridian instruments.

(3) That the best results could only be obtained by combining all the materials in one solution.

After the completion of these extensive experimental researches, Mr. Hinks, with the consent of Sir Robert Ball, wrote to M. Loewy that, if no other astronomer had in contemplation the complete discussion of the Eros observations, he would be glad to undertake it. M. Loewy readily assented to this proposal on condition that Mr. Hinks would include the micrometric as well as the photographic observations in his discussion. Our Medallist then proceeded to discuss all the photographic and micrometric observations of Eros made between 1900 October 1 and 1901 January 19. In this interval the planet described a loop of the sky 50° in length. It is this movement which makes the determination of solar parallax much more intricate and laborious than that of stellar parallax, for which a few neighbouring stars serve as fiducial points for differential measures. Owing to the movement of the planet the stars which are sufficiently near it to serve directly as points of comparison, whether on a photograph or in micrometer measures, are constantly changing. It therefore becomes necessary to determine the relative positions of a large number of stars near the planet's path with great precision. Our Medallist commenced to form a catalogue of the positions of the stars which were most suitable for the purpose of determining the planet's position from day to day. In the case of the micrometer observations, the stars to be employed have been selected once for all by the observer. As regards the photographs, the choice of comparison stars was in some cases determined by the extent of the field. This applied to some extent to the photographs taken at Cambridge, but more to those taken at the Lick Observatory with the Crossley reflector. As regards photographs with sufficient field for the employment of the

reference stars, our Medallist's researches had convinced him, of what is well known now, but was not sufficiently realised when the Eros work was begun, that in photographic measures of the highest precision there is a possibility of small systematic errors depending on the magnitude of the stars. He, therefore, chose as comparison stars, as far as he was able, stars of magnitude not widely different from that of the planet.

The positions of the comparison stars had all to be deduced from the photographs taken at the different observatories. On each plate taken with one of the astrographic telescopes, the reference stars whose positions had been determined by meridian observations served to determine the positions of other stars on the same plate. Mr. Hinks therefore commenced by a careful and exhaustive study of the positions of the reference stars. They were 671 in number, and had been well observed on the meridian at 30 different observatories. As each photograph gives the position of the reference stars *inter se*, it furnishes material for correcting the meridian observations. Accidental errors may in this way be smoothed down, and one important systematic error to which meridian observations are liable, namely, magnitude equation, can be almost entirely determined and eliminated. Mr. Hinks proceeded therefore to form a catalogue of the reference stars based on the photographic measures. The formation of this catalogue led to a very valuable criticism of both the meridian and the photographic observations.

The meridian observations made at the different observatories were collected and published by M. Loewy. They were discussed by Professor Tucker of the Lick Observatory, and a normal system derived from them. Later they were again discussed by Dr. Cohn, who endeavoured to free the right ascensions from magnitude equation by the aid of comparisons with his own observations at Königsberg made with a Repsold travelling micrometer. Meanwhile photographic positions of the reference stars had been derived from the plates taken at Algiers, Bordeaux, Catania, Greenwich, Helsingfors, Northfield, Paris, San Fernando, and Toulouse. Our Medallist compared their results *inter se*, and found that, with the exception of Algiers, and, to a much smaller extent, San Fernando, there was little evidence of any magnitude equation in right ascension between the photographs of the different observatories. Comparison with Professor Tucker's catalogue showed that it possessed a considerable magnitude equation, and a similar result held for the meridian places adopted in the reduction of the plates taken at the French observatories, which may be called M. Loewy's system. An analysis of Dr. Cohn's catalogue showed a magnitude equation in the stars of highest declination, but not in the remainder. The amount was determined as $-0^{\circ}.017$ per magnitude, the sign indicating that the fainter stars are observed too early relative to the bright ones, a result opposite to that generally found with transits. The declinations were next examined for magnitude equation. The meridian observations were found to be free from

this, but the photographs taken at Toulouse showed a considerable equation, and those taken at San Fernando a small one. The errors at Algiers and Toulouse pointed out by our Medallist led the directors of these observatories to examine the mounting of the object-glasses, with the happy result that the causes of the errors were discovered and removed. Examination was next made for progressive differences varying from point to point along the path of the planet. These were in some cases considerable, and were attributed in large measure to differences in the adopted right ascensions and declinations of the reference stars at the different observatories. Mr. Hinks therefore determined to apply corrections to bring the reductions of all the photographs into harmony with the system employed at Paris and other French observatories, and subsequently at Greenwich. He addressed to the directors of the various observatories a request that they should furnish him with the coordinates of the reference and comparison stars deduced from each plate separately. This request was readily acceded to by the directors of the different observatories, and with the material thus put at his disposition Mr. Hinks formed, first, a provisional standard from the results obtained at Greenwich, Paris, and Toulouse. With this he compared the positions found on each separate plate at the observatories of Bordeaux, Helsingfors, Northfield, San Fernando, and Toulouse, and derived the corrections necessary to reduce them to his standard. After this had been done he investigated the magnitude corrections to be applied to the observations of San Fernando and Toulouse. He finally combined the positions obtained at eleven different observatories, giving double weight to the results obtained at Bordeaux, Greenwich, and Paris. He thus obtained a standard photographic catalogue of 671 reference stars, and of about 6000 comparison stars, based on not less than 60,000 observations. To its formation our Medallist devoted the greatest care and patience, as it was intended to be the basis of his determination of the positions of the planet whether observed photographically or visually. As far as possible, all positions of the planet were deduced from the comparison stars, and not from the more distant and brighter reference stars. At Bordeaux, Paris, Helsingfors, Toulouse, and San Fernando reference stars had been employed in obtaining the positions of the planet, published in the Paris circulars. But these observatories also measured the positions of a number of stars within a square of 20', having the planet at the centre. Among these were always found a number of comparison stars contained in the standard photographic catalogue which our Medallist had formed. By taking the differences between the observed positions and those given in the catalogue, corrections were found, which, when applied to the published right ascensions of the planet, referred them to the normal system. At the same time this method corrected the systematic errors which the plates of several series contained. The places of the planet on the Greenwich plates were already reduced to a system of comparison

stars whose positions were in good agreement with those of Mr. Hinks' catalogue. The plates taken at Cambridge and Oxford were not measured till after the formation of the catalogue, and the positions of the planet derived from them were therefore directly reduced to this system. The important series of plates taken with the Crossley reflector at Mt. Hamilton required special provision. Comparison stars suitable to the small field of good definition of this telescope, which is not more than 12' in radius, were chosen by Mr. Hinks during the formation of his catalogue. With the addition of a number of stars measured specially for the purpose, it was found possible to provide from 8 to 12 comparison stars for each plate, and thus ensure the accurate reduction of these photographs. The comparison stars of most of the micrometric observations also found a place in the normal catalogue.

This completes the first and most laborious part of our Medallist's task. He has now provided the means for reducing the observations of the planet to a uniform system by means of suitable comparison stars. The apparent right ascensions and declinations of Eros as seen at various hour-angles east and west and from different stations on the Earth's surface are next deduced. The comparison of the positions with one another gives the parallax of the planet, and thence that of the Sun. At first sight this would appear to be a very complicated process, as the planet is both moving in the sky and also changing its distance from the Earth. The method of procedure may be described somewhat as follows:—The position of Eros in the solar system, deduced from the opposition of 1900 and earlier observations, is summarised by the investigations of M. Millosevich, Dr. Witt, and others in the form of *elements* of the planet. From these elements the coordinates of the planet relatively to the Sun may be calculated, on a scale in which the Earth's distance from the Sun is taken as unity. Combining these with the coordinates of the Sun relatively to the Earth, an ephemeris is constructed giving the right ascension and declination of the planet as seen from the Earth's centre, and also its distance from the Earth in units of the Sun's mean distance. Such an ephemeris forms the standard with which the observations are directly compared, and thus indirectly with one another. In making this comparison it is convenient to assume that the Solar Parallax is approximately $8''.80$, and that this value requires correction by a small unknown fraction, say P times of itself. The value $8''.80$ is sufficiently accurate to make the correction for planetary aberration. Each observation of the planet is corrected for parallax, assuming it to be $8''.80 (1 + P)$. When a comparison is now made with the ephemeris, each observation gives a simple equation with two unknown quantities, namely, P , the small fraction we are seeking to find, and a second unknown quantity which is the residual error of the ephemeris at the time of the observation.

It is clear that for the purpose of determining the Solar Parallax a small constant or slowly changing error in the

ephemeris is of no consequence, but that any rapid changes in its error should be guarded against. But as our Medallist had in view the determination of the Moon's Mass as well as that of the Solar Parallax, it was necessary that particular care should be taken in the calculation of the ephemeris as far as it depended on the monthly revolution of the Earth's centre about the centre of gravity of the Earth and Moon.

An ephemeris of the planet based on Professor Millosevich's elements was published in the ninth Eros circular. At the request of Professor Turner and Mr. Hinks the ecliptic rectangular coordinates of the Sun and planet which are formed in the preparation of the ephemeris were also published. In his experimental investigation Mr. Hinks used these coordinates in preference to the right ascensions and declinations of the geocentric ephemeris, and discovered an inconsistency between them. He drew M. Loewy's attention to the discordance, which was traced to the employment of different values of the obliquity of the ecliptic in transforming to equatorial coordinates. This was corrected in the twelfth circular, where, in addition, a table was given to reduce the ephemeris to one based on new elements calculated by Dr. G. Witt, in which a more complete account was taken of planetary perturbations. Some small errors in the ephemeris, when thus corrected, were discovered and put right, thanks to the careful examination and criticism to which it was subjected by our Medallist. He was still doubtful whether the lunar equation had been calculated with precision sufficient for the ephemeris to be used for a redetermination of the Moon's Mass, and drew M. Baillaud's attention to the difficulty. M. Baillaud, in that kindly spirit of co-operation which all who have attended conferences at Paris appreciate so highly, thoroughly investigated the question, and, in the end, decided to compute a fresh ephemeris. He entrusted the task to M. Lagarde, who carried it out with great skill and rapidity. M. Lagarde calculated the positions of the planet, as seen from the centre of gravity of the Earth and Moon, for every six hours, and referred them to the Earth's centre as origin by aid of formulæ, given by Newcomb in the *Astronomical Papers of the American Ephemeris*. To make the ephemeris immediately applicable to a redetermination of the Moon's Mass, he gave the Earth-Moon terms separately.

Besides the examination of the ephemeris, Mr. Hinks carefully scrutinised the methods and constants employed in the reduction to apparent place. The short period nutation terms, being included in the Independent Day Numbers of the American ephemeris, were calculated by some astronomers, but were not included in the ephemeris of the planet. Again, the change in the constants of precession, aberration, and nutation, introduced into the *National Ephemerides* in 1901, occasioned a good deal of diversity. In fact, the number of methods employed was equal to the number of observatories engaged in the reductions. Mr. Hinks corrected all cases in which any appreciable error was

introduced, due to differences between the methods of obtaining apparent places from observations, and in forming the ephemeris.

After these various corrections had been made, each observation was compared with the ephemeris, giving, as I have said, a simple equation with two unknown quantities, viz., the error of the ephemeris at the moment of observation, and the correction to the adopted value of the Solar Parallax. It is first necessary to investigate the errors of the ephemeris. Combining together all the observations of a single day, the effect of the parallax is practically insensible in the mean, as it has a different sign for the evening and morning observations, and only the errors of the ephemeris remain. The errors thus determined were found to vary somewhat irregularly, partly owing to the movement of the planet in declination, partly because the residual errors of the adopted star places are included in them. The errors were plotted down for each day, and a curve drawn through the plotted points, following the larger, but neglecting the smaller sinuosities.

Comparison with the new ephemeris calculated by M. Lagarde was found to be much smoother than with the old one. But even with this ephemeris it was clear that no algebraic expression could be obtained which would represent the errors satisfactorily. To fortify the graphical solution, Mr. Hinks divided the curve into sections at the points where the lunar equation vanishes, and determined by a least square solution the error and rate of change of error in each section. He thus obtained a series of straight lines which agreed with the curve in these portions, and, by modifying them graphically at the junctions, he obtained a curve which represented the errors satisfactorily for the parallax determination. It is the changes of the error of the ephemeris, in the short intervals from the evening to morning and morning to evening, which are of importance for the purpose of this investigation.

This troublesome and difficult question having been resolved, Mr. Hinks determined the parallax from the material at his disposition in a large number of different ways. Taking first the ephemeris of M. Loewy, and dividing the observations into groups of four days, and afterwards combining the separate values according to their weights, he obtained $+''\cdot0055$ as a correction to the parallax $8''\cdot80$. Taking each observatory separately, and afterwards combining the results, he obtained the correction $+''\cdot0086$.

With the new ephemeris he again divided the observations into groups of four days and obtained a value $+''\cdot0019$. In groups of one day he obtained $+''\cdot0041$. Taking the observatories separately and afterwards combining them, $+''\cdot0073$. The computation of the new ephemeris was amply justified by the difference made in the separate solutions. Generally speaking, the results given by the separate observatories are altered considerably, and on the whole made more accordant. These results of the separate observatories are very interesting. Only a few are of sufficient weight to give a good determination of the parallax by themselves,

but the series obtained at Greenwich, Lick, Cambridge, and Paris have sufficiently small probable errors to make the differences between them worth consideration. This applies specially to the Greenwich and Lick Observatories, whose probable errors were found by Mr. Hinks to be $\pm''\cdot0043$ and $\pm''\cdot0046$ respectively. From Greenwich a value just below $8''\cdot800$ was obtained, and from Lick one just under $8''\cdot815$. Mr. Hinks is inclined to attribute the difference to the fact that at Greenwich the comparison stars were slightly brighter than the planet, and at Lick considerably fainter. After carefully weighing the merits of the different solutions, Mr. Hinks concluded that the best result was $+''\cdot007$, thus giving as the Solar Parallax $8''\cdot807$, with a probable error of $\pm 0''\cdot0027$. This probable error is an extremely small angle; it is equivalent to an arc of $3\frac{1}{2}$ inches long on the circumference of the Earth.

Our Medallist next discussed the visual observations of Eros. These fall into classes—those in which the transit of the planet and comparison stars were observed with the instrument fixed, and those in which distances and position angles were measured, the instrument being driven by clock work. Observations of transits were made at six observatories; in particular, a very fine series were made at Nice by M. Perrotin. Mr. Hinks went thoroughly through all the material, considering the possibility of such sources of error as personality depending on the magnitudes. The observations at Nice taken by themselves gave for the parallax $8''\cdot814$, but with the large probable error of $\pm 0''\cdot031$. When all the transit observations were taken together, the value $8''\cdot837$, with probable error of $\pm''\cdot0185$, was given.

The micrometer measures gave a much more accurate result. Eleven different series of measures were discussed; but Professor Barnard's observations at Yerkes, Professor Comstock's at Washington, and several shorter series could not be dealt with, because the published reductions were incomplete. The most important of the series discussed are those of Professor H. Struve at Königsberg, Professor Hussey and Dr. Aitken at Lick, M. Cerulli at Teramo, and Dr. See at Washington. The observations were divided into 8 groups of 14 days, defined by the dates on which the lunar equation vanished. Each group was solved separately, so as to give the residual error of the ephemeris and correction to the parallax. The results were then combined in various ways to obtain the final solution. Mr. Hinks also treated separately the four long series of observations, and exhibits some interesting systematic differences between them. After carefully weighing all the evidence of the many solutions, he concludes that the most probable result obtained from the visual observations is $8''\cdot806 \pm \cdot004$. This value of the Solar Parallax is practically identical with the value found from the photographs. It has a larger error, but still an extremely small one.

A determination of the Mass of the Moon is a natural sequel to the discussion of a long series of observations from the Solar Parallax, and is in some respects a more difficult problem. As

the period of the inequality from which the Mass of the Moon is determined is one month, and only a few periods are included in the whole series of observations, systematic errors in the ephemeris and in the adopted star places may have a much more serious effect than is possible in a determination of the parallax. The ephemeris, as we have seen, had been calculated *de novo* by M. Lagarde. But even this ephemeris was open to the possible objection that the position of the Earth relatively to the Sun was not obtainable with sufficient precision from Newcomb's Solar Tables. This constituent of the ephemeris was recalculated by M. Lagarde by the numerical method of special perturbations, which gives the highest accuracy for a limited interval of time.

As a check on the possibility of errors being introduced through the adopted star places, Mr. Hinks made two determinations of the Moon's Mass, using first his own standard photographic catalogue, and, secondly, correcting it to the system of Dr. Cohn. His reasons for this course were that, though the standard photographic catalogue was entirely satisfactory for the purpose of determining the parallax, it might have small systematic errors in right ascension. For it is based ultimately on M. Loewy's meridian places, which are affected by a magnitude equation. If the mean magnitude of the reference stars is $8^m.5$ in one part of the planet's path, the photographic right ascensions treat $8^m.5$ stars as having a zero magnitude equation. If in another place the mean magnitude of the reference stars is $8^m.2$, here an $8^m.2$ star is considered as having no magnitude equation: there is a small discordance between these two parts of the catalogue, amounting to the difference of magnitude equation of an $8^m.2$ and an $8^m.5$ star. Further, if there is a systematic error in the right ascensions of the reference stars, depending on declinations, this will necessarily have been reproduced in the photographic standard catalogue. These interesting points illustrate the care with which our Medallist considered each possible source of error.

Recognising the advantage of a separate determination based on an independent star system, he formed the differences between his own and that of Dr. Cohn, and applied them to the differences between the observed right ascensions of Eros and those calculated from the ephemeris of M. Lagarde. The residuals between the tabular and observed right ascensions were then solved in several different ways so as to give a correction to the coefficients of the lunar equation. Substantially the same result was given by Dr. Cohn's and Mr. Hinks' system of stars. It was found that the coefficient of the lunar equation needed to be increased by the fraction $\frac{1}{11800}$ of itself. From this the ratio of the Earth's Mass to that of the Moon was inferred to be 81.53 ± 0.47 . From this value of the Moon's Mass new values were obtained of the constant of nutation, and of the mechanical ellipticity of the Earth. Thanks to our Medallist's researches these quantities are now known to about one part in 1800, or between twice and three times as accurately as formerly.

A very short and interesting account of our Medallist's researches was given by him in the form of a report to the Paris Conference of 1909, and is published in the reports of the meetings. A fuller discussion is given in the *Monthly Notices* in a series of nine papers extending from November 1901 to November 1909. Full details are not given, but the methods employed are carefully explained, and the material is exhibited in such a manner as to give a clear idea both of the accidental error and the various systematic errors which had to be eliminated. There is, I believe, general agreement that the extensive series of observations which were taken at the opposition of Eros have been used to their fullest extent, thanks to the skill, patience, and industry of Mr. Hinks. The Mass of the Moon has been determined, it seems to me, within the limits of the assigned probable error. The same would be true of the Solar Parallax, but for one factor to which different people will attach different importance. If the mean wave-length of the light forming the photographic images of Eros differs by 10 tenthmetres from that of the comparison stars, then at a zenith distance of 45° there will be a difference of refraction of $0''.008$, and at 60° of $0''.014$. This would make the deduced parallax too great by $0''.003$ or $0''.004$. Sir David Gill has found that with the heliometer observers match the colours in measuring the distance between two star images dispersed into small spectra and thus avoid any systematic error due to difference of colour. It may be that in the micrometric observations of Eros any effect due to dispersion is similarly eliminated, but this has not been demonstrated. In the photographic observations it is difficult to see how this effect, if it exists, can be entirely eliminated till the progress of photography can supply plates sensitive to a very limited range of spectrum about G. The agreement between the visual and photographic results, obtained by Mr. Hinks, makes it probable that the effect of dispersion is very minute, as otherwise it is not likely to be of the same amount in visual and photographic observations. Further, the very interesting experiments made by M. Prosper Henry gave a difference of wave-length of 20 tenthmetres between Eros and neighbouring stars, but in a sense opposite to the one which would be expected from the fact that Eros reflects the light of a second type star. I have ventured to draw attention to this small uncertainty, which is inherent in the determination of the Solar Parallax from photographs of Eros, as further research on the lines of M. Prosper Henry may serve to remove it.

I will now summarise what are, I believe, the grounds of your Council in awarding the Medal to Mr. Hinks. The long and valuable series of observations of Eros have been reduced by him with the greatest skill and perseverance. On his own initiative he undertook, and has now successfully carried out, the co-ordination of a very extensive and heterogeneous collection of astronomical observations. He has thus completed a great international undertaking, to which many astronomers contributed and in which all

are interested. His work has been a valuable criticism of the requirements of astronomical photography. It has shown what high precision can be obtained, and in many details his example and experience will be useful to others engaged in similar work. His researches have centred around that great historical problem, the determination of the Sun's distance; they have made a substantial addition to the reliance to be placed on the trigonometrical method as opposed to those depending on gravitational astronomy or on the constant of aberration; and they have determined this most important of all astronomical constants with the greatest accuracy hitherto attained.

Mr. Hinks,—It rarely happens that the President of the Society has the pleasure of handing this Medal to one of the Secretaries. You have already received a mark of the high appreciation in which your work is held by French astronomers. I am sure you will value no less this tribute from your own countrymen. In presenting to you the Gold Medal of the Royal Astronomical Society, allow me to congratulate you on the successful completion of your great enterprise, and to express the belief, which is shared by all your colleagues, that your services to astronomy in the future will be of an equally high order.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected :—

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